DESIGNING FOR DEEP TIME: HOW ART HISTORY IS USED TO MARK NUCLEAR WASTE

by

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TABLE OF CONTENTS

Cha	apter One: LOOKING TO THE PAST TO SOLVE FUTURE PROBLEMS1		
Chapter Two: SCENARIOS: ESTABLISHING CONTEXT, INVENTING CULTURE10			
Chapter Three: INFLUENCES: ESTABLISHING PRECEDENCE			
Chapter Four: THE PRESENT AND FUTURE LANDSCAPE OF THE WIPP			
Chapter Five: ART FOR A FUTURE PUBLIC			
Appendix A: SITE DESIGN GUIDELINES			
BIBLIOGRAPHY90			
LIST OF ILLUSTRATIONS Note: Physical location or published location of images is indicated as marked.			
1.	Project Gnome Marker, Carlsbad, New Mexico96		
2.	<i>Example of the Calculation of the Probability of Occurrence of a Scenario</i> , from R. V. Guzow and M. M. Gruebel, ed., <i>Background Information Presented to the Expert Panel on Inadverten Human Intrusion into the Waste Isolation Pilot Plant</i> (Albuquerque: Sandia National Laborato 1991), pl. 2.3	vski at ories,	
3.	Techniques for Assessing and Reducing Uncertainty in the WIPP Performance Assessment, from R. V. Guzowski and M. M. Gruebel, ed., Background Information Presented to the Expert Para Inadvertent Human Intrusion into the Waste Isolation Pilot Plant (Albuquerque: Sandia Nation Laboratories, 1991), pl. III-I	om <i>nel on</i> nal	
4.	<i>The Mole Miner</i> , from Gregory Benford, <i>Deep Time: How Humanity Communicates Across Millennia</i> , 1 st ed. (New York: Perennial, 1999), pl. 1.1		
5.	<i>The Pyramids of Menkaure (c. 2533-2515 B.C.), Khafre (2570-2544 B.C.), and Khufu (c. 2601 2528 B.C.),</i> Giza, Egypt	!-	
6.	North-south section of the Pyramid of Khufu, from Anthony F. Janson, History of Art, 6 th ed. (1 Jersey: Prentice Hall, 2004), pl. 2-11	New	
7.	Stonehenge (aerial view), Salisbury Plain, Wiltshire, England102		
8.	The Great Wall of China, China		
9.	Great Serpent Mound, Adams County, Ohio104		
10.	Avebury, Wessex, Wiltshire, England105		
11.	The Treasury of Petra, Petra, Jordan106		

12.	<i>Options for the Warning Symbol for Nuclear Waste Disposal Sites</i> , from Maureen F. Kaplan, "Mankind's Future: Using the Past to protect the Future; Archaeology and the Disposal of Highly Radioactive Wastes," <i>Interdisciplinary Science Reviews</i> , 11, no. 3 (1986), pl. 6107
13.	<i>Pictograph for the Location of a Repository for Reprocessed High-level Wastes</i> , from Maureen F. Kaplan, "Mankind's Future: Using the Past to protect the Future; Archaeology and the Disposal of Highly Radioactive Wastes," <i>Interdisciplinary Science Reviews</i> , 11, no. 3 (1986), pl. 7108
14.	Pictograph Developed by the Human Interference Task Force Indicating the Consequences of Disrupting the Disposal Site, from "Mankind's Future: Using the Past to protect the Future; Archaeology and the Disposal of Highly Radioactive Wastes," Interdisciplinary Science Reviews, 11, no. 3 (1986), pl. 8
15.	The Parthenon, Athens, Greece
16.	The Phaestos Disc, Archaeological Museum, Heraklion, Crete, Greece111
17.	Painting of Human Handprints about the Edges of Paintings of Horses in France's Pech Merle Cave, Pech Merle, France
18.	The Birdman from Lascaux, Lascaux, France113
19.	Flotilla Fresco, National Archaeological Museum, Athens, Greece114
20.	Isotype, from the New Deal Network, http://www.newdeal.feri.org/survey/37025.htm115
21.	Imagery from Voyager, from Edward Tufte, Visual Explanations: Images and Quantities, Evidence and Narrative, (Cheshire, Conn.: Graphics Press, 1997), pl. 27116
22.	Upper Strip Looking North, from Robert Venturi, Denise Scott Brown, and Steven Izenour, Learning from Las Vegas: The Forgotten Symbolism of Architectural Form, (Cambridge: MIT Press, 1977), pl. 36
23.	Computer Kiosk Interface Design for the National Gallery in Washington, from Edward Tufte, Visual Explanations: Images and Quantities, Evidence and Narrative, (Cheshire, Conn.: Graphics Press, 1997), p 47
24.	Elements of Legibility
25.	Variations on Triangles and Circles, from Percy H. Tannenbaum, Communication Across 300 Generations: Deterring Human Interference with Waste Disposal Sites, Columbus, Ohio: Office of Nuclear Waste Isolation, Battelle Memorial Institute, 1984, pl. 1
26.	Mail, American Institute of Graphic Arts, from Symbol Signs: The Development of Passenger/Pedestrian Oriented Symbols for Use in Transportation-related Facilities, Washington, D.C.: Dept. of Transportation, Assistant Secretary for Environment, Safety, and Consumer Affairs, Office of Facilities, 1974, p.16
27.	<i>Telephone</i> , from <i>Symbol Signs: The Development of Passenger/Pedestrian Oriented Symbols for</i> <i>Use in Transportation-related Facilities</i> , Washington, D.C.: Dept. of Transportation, Assistant Secretary for Environment, Safety, and Consumer Affairs, Office of Facilities, 1974, p.14
28.	Symbol Evaluation Chart, from Symbol Signs: The Development of Passenger/Pedestrian Oriented Symbols for Use in Transportation-related Facilities, Washington, D.C.: Dept. of Transportation,

	Assistant Secretary for Environment, Safety, and Consumer Affairs, Office of Facilities, 1974, p.13-14
29.	Exterior of the WIPP, Chihuahuan Desert, New Mexico
30.	Satellite Image of the WIPP, Chihuahuan Desert, New Mexico
31.	Waste Isolation Pilot Plant, Chihuahuan Desert, New Mexico
32.	<i>Waste-handling Building</i> , from R. V. Guzowski and M. M. Gruebel, ed., <i>Background Information</i> <i>Presented to the Expert Panel on Inadvertent Human Intrusion into the Waste Isolation Pilot Plant</i> (Albuquerque: Sandia National Laboratories, 1991), pl. II-6
33.	Transuranic Nuclear Waste Housed 2,150 feet below the Earth's Surface, WIPP, Chihuahuan Desert, New Mexico
34.	<i>Black Hole</i> , from Michael Brill, <i>Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years</i> , Buffalo, New York: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 8
35.	<i>Black Hole,</i> from Michael Brill, <i>Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years</i> , Buffalo, New York: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 9
36.	<i>Rubble Landscape</i> , from Michael Brill, <i>Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years</i> , Buffalo, New York: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 10
37.	<i>Rubble Landscape</i> , from Michael Brill, <i>Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years</i> , Buffalo, New York: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 11
38.	<i>Spike Field</i> , from Michael Brill, <i>Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years</i> , Buffalo, New York: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 6
39.	<i>Spike Field</i> , from Michael Brill, <i>Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years</i> , Buffalo, New York: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 7
40.	Spikes Bursting Through Grid, from Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years, Buffalo, New York: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 14
41.	Spikes Bursting Through Grid, from Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years, Buffalo, New York: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 15
42.	Leaning Stone Spikes, from Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years, Buffalo, New York: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 19
43.	Landscape of Thorns, from Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years, Buffalo, New York: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 1

- 53. Tilted Arc, destroyed, formally at the Javits Federal Plaza, New York City......148

Chapter One: Looking to the Past to Solve Future Problems

Ars Longa, Vita Brevis¹

Art is long, life short. Art has long been considered a way to escape our own mortality. Just as technological inventions serve as an extension of our physical capabilities, art objects function as an extension of our spiritual selves after death. Future generations will know our culture by what we leave behind; these objects serve as our ambassadors to our descendents. Likewise, we characterize past civilizations according to the objects they have left behind. In piecing together the construct of history, historians and anthropologists have come to associate each successive epoch with characteristic materials and technologies, which represent the industrial accomplishments of the time period and epitomizes the activities and values of its people.

Although hardly eclipsed, our present era has already been dubbed the "Information Age." It gains its title from both the value placed on the transfer of information, as well as its prolific outpouring of technologies facilitating communication. Competing with the notion of boundless communication however, is our culture's tendency toward the ephemeral. These two concepts are undoubtedly linked by the value of innovation, whose side effect is a never-ending cycle of obsolescence. Sophisticated means of production naturally accelerate the cycles of consumption, encouraging a somewhat disposable predisposition towards objects. Furthermore, this sense of the ephemeral travels from physical objects to pervade the very information systems that characterize our age. The substrates on which we store information — our floppy discs, cd-r's and acid-infused paper seem incredibly vulnerable in contrast to the solid diorite slab on which the Law of Hammurabi was transcribed in 1760 BC Furthermore, as communications and information transfer have been popularized, our means of communications have also been abstracted and mystified. In societies where oral tradition is used to transmit information, the entire community is engaged in cataloging information, whereas only a small part of our present population fully comprehends the code of 1's and 0's in which information is transferred and catalogued across the internet. Correspondingly, the organizational metaphor for our information transfer systems has shifted away from natural logic - no longer being tied into the permanent natural world that guided the early calendar and counting systems

and towards a paradigm based on the digital logic of ever-evolving computer programming
languages. In the transfer of information, permanence evades us. Thus, in the midst of the information
age, it appears that we may be losing our ability to transmit enduring messages to future generations.
This is a particularly ill-timed development, since for the first time in history we have a pressing
warning to communicate about future dangers.

This message relates to our trash heaps. Since 1945, the US Department of Energy (DOE) has produced a copious amount of nuclear waste without a clear plan for its disposal. The US is not alone in this dilemma; it is now sixty years into the use of nuclear power and no country in the world has formed a permanent plan for the disposal of radioactive wastes.² In the innumerable studies done on nuclear waste disposal, scientists have proposed three basic solutions. The first — dropping cans of nuclear waste into ocean subjection zones — would inevitably create international policy problems and could allow leakages into the earth's water supply.³ Scientists have also suggested launching the barrels of waste into the sun where they would instantly disintegrate. However, given the statistics — we have over 800,000 barrels of nuclear waste to date, and even the best rockets fail 1% of the time — this is not the most popular idea. In fact, the only idea to survive scrutiny is to dispose of the waste in the same way people have always disposed of waste — by burying it.

The interment location, along with the corresponding project of burying the waste, has been dubbed the Waste Isolation Pilot Plan (WIPP). "Pilot" is perhaps the most revealing term in its title — a way of saying two things at once: "This is but the first' plus 'We believe it will work, but...'"⁴ The uncertainty raised is not in regard to the location — the WIPP is located twenty-six miles outside of Carlsbad, New Mexico. The land is now suitable only for cattle ranching although 240 million years ago, the area was covered in a slowly evaporating ocean, which left behind vast salt mines. These mines, 2,150 feet below the surface of the WIPP facility, provide an inert interment location for the barrels of waste. Theoretically, the intense heat given off by the radioactive materials will melt the salt, causing it to flow and ultimately encapsulate the barrels, which will prevent the possibility of the waste leaking into groundwater. This seems the safest option, provided that the site is left alone.

¹ Hippocrates, c. 347 BC.

² Gregory Benford, *Deep Time: How Humanity Communicates Across Millennia* (New York: Perennial, 1999), 35.

³ Ibid.

⁴ Ibid, 36.

However, considering the propensity of humans to dig — for industrial as well as academic purposes - the waste's continued isolation seems unlikely. Thus, in regard to the WIPP site, the Environmental Protection Agency (EPA) has required by law that the DOE must implement markers for the site, clearly warning against the danger resting underfoot. These markers must remain for the entire period the waste is hazardous, meaning that the markers will need to be understood by people 10,000 years from now — until the unlikely-sounding year 11,996 AD. Based on the hope that our age of information can leave more than a threat to future generations, the DOE has culled together panels of experts to determine how to create a long-lasting nonverbal warning system.

In 1983, the US Nuclear Regulatory Commission (NRC) voiced its opinion on how this might be accomplished through legislation requiring "permanent warning markers" above all nuclear waste repositories.⁵ The DOE responded by establishing the Human Interference Task Force (HITF) to produce individual reports on communication, which could be used to inform the design of a message system. The actual design work was relegated to the WIPP, a subsequent group also formed by the DOE, comprised of three expert sub-panels. The first, a Futures panel was assigned the challenging task of outlining the possible geologic, technological, and political futures of the region immediately surrounding the Carlsbad repository. Headed by astrophysicist and science fiction writer Gregory Benford, the panel formed working assumptions to be utilized by subsequent design Markers design teams A and B. These Markers teams took the recommendations presented by the HITF as well as the future scenarios presented by the Futures panel and formed proposals for the immensely long-lived "Keep Out" sign.

From the outset of the WIPP project, one thing was clear: language was not going to be very helpful here. Language, which is highly sensitive to political and cultural shifts, tends to deteriorate quickly. In fact, linguists have found that languages "decay" as quickly as 12% every century meaning that after 10,000 years, or 100 centuries, we can expect that our current world languages may have decayed by as much as 1200%.⁶ More optimistic statistics suggest that by the year 12,000 AD,

⁵ Percy H.Tannenbaum, Communication Across 300 Generations: Deterring Human Interference with Waste Deposit *Sites*, (Columbus: Office of Nuclear Waste Isolation, Battelle Memorial Institute, 1984), 3. ⁶ Tom Vanderbilt, "Do Not Enter," *Architecture*, 90, no. 9 (2001) 150.

by the world's natural languages."⁷ In spite of the probability that our current world languages will deteriorate at a significantly faster rate than our waste, however some languages appear to possess a longer shelf life than others. Linguistics expert Jonathan Drake notes that languages of religion are most likely to survive. "There are still millions of people who understand Arabic written in the Koran, whereas few are fluent in Old English."⁸

Part of the challenge in divorcing ourselves from a dependence on language-based communication is that it is ubiquitous in our culture. In her book, *Before Writing*, Schmandt-Besserat notes our reliance on written language

Writing is regarded as the threshold of history, because it ended the former reliance upon oral tradition, with all the inaccuracies it had entailed. Business and Administration are now inconceivable without bookkeeping...writing allows us to capture our ideas ...and scrutinize them, revise, add, subtract, and rectify them to arrive at a rigor of logic and a depth of thought otherwise impossible.⁹

Indeed, verbal communication permeates not only the act of writing, but also creates a framework within which we consider and interact with the world. Kastner notes that in every act of communication we initiate, we never begin with a blank slate, but rather with a highly sophisticated verbal structure.¹⁰ Author and National Public Radio contributor Andrei Codrescu once famously noted that

The real technology — behind all our other technologies — is language. It actually creates the world our consciousness lives in.¹¹

The challenge of communicating without language is challenging precisely because of its ubiquitous nature — it is more than just a format of communication, but defines how we perceive and structure the world. Kastner presents the challenge of the WIPP marker design teams to the viewer:

⁷ D. B. Givens, "From Here to Eternity: Communication with the Distant Future," *Et cetera*, 39, Summer (1982), 171. ⁸ Gary Kliewer, "The 10,000 Year Warning: Alerting Future Civilizations about our Nuclear Waste," *The Futurist*, 26, no. 5 (1992): 18.

⁹ Denise Schmandt-Besserat, *Before Writing*, 1st ed. (Austin: University of Texas Press, 1992), 1.

¹⁰ Jeffrey Kastner, "Deep Time Design," *Public Art Review*, 11, no. 1 (1999): 11.

¹¹ Sysprog.net, "Quotes," http://www.sysprog.net/quotwrit.html.

Try to conceive of a format sufficiently clear and universal to transmit a message across ten millennia of sociological, linguistic, and cultural change. Now imagine that this message is one of utmost importance, literally a matter of life and death.¹²

This presents a formidable communication design challenge, as designers (like writers, readers, and artists) rely on a common baseline of language and shared cultural experience in order to produce meaning. Thus, the marker design project is something of a visionary pursuit — one that is simultaneously necessary and impossible. Resembling a trick question or unfortunate riddle, overcoming 10,000 years of uncertainty became the primary activity of the WIPP design team. They sought to determine what kinds of messages are capable of enduring ten millennia of essentially unpredictable change. In their project, the researchers posited many intriguing questions concerning the limits of communication. Verbal communication seemed inadequately short-lived, and was thus dismissed as an unviable strategy by most of the reports. While some proposals were made to utilize olfactory rather than visual messages, the reports generally concur that visual, non-verbal messages would be most permanent. A study by an HITF communications expert notes "while there are occasional exceptions to the dominance of visual and tactile senses, all indications are that these are the most suitable modalities to employ for both technological and recipient purposes."¹³

Although the dominance of visual communication is uncontestable, what is its long-term effectiveness? Do these types of messages, like verbal messages, have an expiration date? Are they completely dependent on cultural context and associations? These types of unanswerable questions, pursued by the WIPP design team, are not typical questions one asks in a design process. They are usually relegated to the field of semiotics. Whereas designers create communications, semioticians study communications — both linguistic and nonverbal.

Designers, working within specific types of communication are generally not required to examine these programs and their assumptions from the outside looking in. Normally, a design project would only necessitate a "semiotics" approach when information is missing. However, for all practical purposes, this never happens. The discipline of design begins with an intimate knowledge of the problem to be solved, so that an appropriate solution can be tailored to meet it. The problem itself establishes the parameters and guidelines. In the case of communication design, the particular

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objectives are formed according to the perceptual capabilities of the message recipient. Percy H. Tannenbaum writes that the message needs to appeal to the senses of the recipient on an appropriate cognitive, physiological, aesthetic, and linguistic level. In this sense, design is wholly focused and dependent on the audience for its guidelines. When, as in the WIPP design project, the message recipient is absent from the equation, the form/function formula is obliterated. Thus the question becomes: how does communication design occur when the message recipient is unknown? Is it still "design" when the message cannot be tailored to meet the specific requirements of the recipient? These sorts of challenges are characteristic of designing for long periods of time. There is a term used to describe design messages for a temporally distant recipient: "deep time design."

"Deep time design" is an extension of the term "deep time" coined by geologist John McPhee in his 1981 book, *Basin and Range*.¹⁴ Deep time, a parallel term to "deep space," seeks to "communicate the full dimension of geologic time."¹⁵ Deep time design, therefore, refers to design that functions on a geologic timeframe rather than a human timeframe. Although "deep time design" is a new term, the concept is ancient. The Great Pyramids of Giza, for example, can be said to fulfill a deep time objective; they were constructed to permanently house the pharaoh's body, as the survival of the soul in the afterlife was linked to the survival of the body.¹⁶ Additionally the desire to preserve knowledge for future generations may be a universal human impulse, often prompting deep time design endeavors throughout history.¹⁷ Benford suggests that the practice "springs from a class that feels it has accomplished much and has the resources to leave durable messages conveying this."¹⁸ Although these ancient civilizations lacked an equivalent term for "millennia" or "deep time", the concept of disposability was also likely to be foreign. Their success at designing for geologic time may help modern message-writers rediscover permanent materials and strategies for communication with the distant future.

¹³ Tannenbaum, 17.

¹⁴ Paul Zweig, 'Book Review Corner,' *The New York Times*, Sunday 17 May 1981, Late City Final Section 7, pg. 1. ¹⁵ Ibid.

¹⁶ Maureen F. Kaplan, "Mankind's Future: Using the Past to Protect the Future; Archaeology and the Disposal of Highly Radioactive Wastes," *Interdisciplinary* Science Reviews, 11, no. 3 (1986), 258. The pyramids were purposely shaped to resemble a ray of the sun — as the pharaohs were thought to be descended from the sun god and were to return to the sun at death.

¹⁷ Benford, 10.

¹⁸ Ibid. As an example, he mentions the thousands of stone tablets commissioned by Assurbanipal, King of Babylonia, Assyria, and Egypt in the 7th century BC — created to carry the knowledge of the day beyond the lifetimes of the king and his subjects.

The decoding abilities of art historians speak to the potency and longevity of nonverbal messages. Most of the reports submitted to the DOE regarding the design of a permanent marker used art historical and archeological objects as primary references. Archaeological objects reveal how messages may be encoded to remain legible over long periods of time. Thus, by rummaging through the refuse and artifacts of past cultures, we discover ways to communicate with future generations to keep them out of our generation's toxic trash heap.

This paper serves as a case-study of the very unique, interdisciplinary design process that occurred in November of 1991, when a panel of experts met to discuss strategies for visually marking nuclear waste. This text will summarize and analyze the findings of the following DOE-commissioned publications leading up to and reporting on the findings of the Marker design panel:

- *Communication Measures to Bridge Ten Millennia*, written by semiotician Thomas Sebeok, serves as a preliminary report on possible strategies for communication over the span of 10,000 years.
- Communication Across 300 Generations: Deterring Human Interference with Waste Deposit Sites, written by communication expert Percy Tannenbaum, suggests that the warning message should take the form of a visual marker.
- Expert Judgment on Markers to Deter Inadvertent Human Intrusion into the Waste Isolation Pilot Plant is the final report from the two expert panels tasked with designing the site marker. Marker Team A was comprised of Dieter Ast, Michael Brill, Ward Goodenough, Maureen Kaplan, Frederick Newmeyer, and Woodruff Sullivan. Marker Team B was comprised of Victor Baker, Frank Drake, Ben Finney, David Givens, Jon Lomberg, Louis Narens, and Wendell Williams.
- Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years, written by design team member and environmental graphic designer Michael Brill, displays all of the possible design sketches envisioned by the Markers panel.

Based on these reports — as well as independent reports published by the individual team members — this paper will explore the methodology and strategies employed in developing a universal, non-verbal

communication system. Since art historical influences were dominant in informing the groups' methodologies (studying objects, visual communication strategies, and materials conservation issues), they will be granted special consideration.

The DOE's site marker process inverts the usual art history process. Art history typically claims an objective starting point and then broadens outward; the actual physical object precedes studies determining the exact communication strategies that it uses. However, within the DOE's site marker project, social context and communication strategies must first be envisioned — i.e. they must be created before the physical object can be proposed. What this essentially means is that the design teams had. to invent the future cultures before they could make the object.

The DOE implemented a cumulative approach to comply with the provisions, wherein the knowledge gained by one research panel is passed onto the next. By establishing the three aforementioned types of expert panels, undertaking three recommendations processes, wherein each successive report builds upon the findings of the prior reports, they achieved a multidisciplinary approach to the problem. Therefore, although the Human Interference Task Force (HITF) is a different body than the Waste Isolation Pilot Project (WIPP) and is comprised of different expert groups, their findings greatly influenced the research of the WIPP.

Although the cumulative approach to the design process lended a sense of continuation — a sense of precedence — no actual precedents exist for this type of project. The closest instance of precedence is the Project Gnome marker, used to warn against residual radioactivity caused by nuclear experiments of the early 1960s.¹⁹ Not far from the WIPP repository site, a group called Project Plowshare detonated a small warhead 1,000 feet under the ground within a salt flat.²⁰ The stated purpose of the experiment was to heat up the underground rock salt to the extent that the molten mass's heat would pump steam through electrical generators, supplying power. The idea predictably failed as the ground immediately caved in following the blast. One WIPP panel member sarcastically remarked that this sort of ill-conceived experiment exemplified the "golden years of nuclear development, when ideas got tried for size right away rather than spending a decade or so mounting up piles of paper

²⁰ Ibid.

studies."²¹ In spite of the haste with which such an experiment could be executed, its effects were not fleeting. The remains of the failed Project Gnome experiment mar the New Mexico desert in the form of toxic radiation and a single tombstone-sized granite slab. (Figure 1) A copper plaque attached to this marker boastfully lists the names of the scientists and generals involved in the project's implementation. In small type, near the bottom of the plaque is the statement that "this site will remain dangerous for 24,000 years."²² The tiny size of the typeface must have been proportional to their degree of seriousness in ensuring the permanence of the marker. Within the 40 years that have elapsed since the experiment, successive generations of nearby grazing cattle — apparently requiring a post to rub against — have inadvertently moved the marker a couple of meters. The gradual displacement of the marker raises doubts concerning the marker's usefulness to the near future, much less the inconceivably distant future date listed in the ironically small type.

Thus, while the Project Gnome marker technically serves as a precedent to the WIPP marker project, it is little more than a tourist destination today. It stands as a symbol of defaultment — of passing the responsibility of warning on to the next generation. As confirmed by ethicists serving on the Futures panel, as well as public outcry, it is now the present generation's responsibility to find a way to communicate the dangers of nuclear waste to the future. "Risk is not morally transferable."²³ While this might pose the most formidable design challenge of our time, especially considering the current ephemeral nature of information-exchange, in the words of one panel member: "That is the deal we made in haste when we first split the atom."²⁴

²¹ Ibid.

²² Ibid.

²³ Ibid, 44.

²⁴ Martin J. Pasqualetti, "Landscape Permanence and Nuclear Warnings," *Geographical Review*, 87, no. 1 (1997), 14.

Chapter Two: Scenarios: Establishing Context, Inventing Culture

Guidelines Outlined in the Enabling Legislature

The general framework that guided the panels' activities was defined within the legislation requiring the marker. Code of Federal Regulations 40 191 (40 CFR 191), states four basic requirements of the WIPP project and guided the manner in which the teams tackled the design problem:

1. The site must be "designated by the most permanent markers, records, and other passive institutional controls practicable to indicate the dangers and their location." (40 CFR 191.14c)25

This provision requires that permanent markers be constructed with the additional requirement that records also be stored offsite, presumably within the custody of "permanent" institutions. A report outlining the way that institutions could hold information related to the "dangers and location" of waste was published by the Human Interference Task Force in 1982. Entitled Building on Existing Institutions to Perpetuate Knowledge of Waste Repositories, it suggests four institutional approaches to the retention of information, with the assumption that future institutions will be interested in guarding the WIPP site.²⁶ These four strategies include: 1. wide distribution of maps marking the location of the WIPP repository, 2. alerting the National Geodetic Survey (the branch of the Oceanic and Atmospheric Administration responsible for determining exact position of geographical points through the use of geology) of the repository location, 3. the thorough archiving of documents, and 4. the establishment of a universal "one-call" number (similar to that used by the public utility system) which contractors would be required to call before digging anywhere.²⁷ While it is likely that implementing these "passive institutional controls" will not be detrimental to the waste's isolation, it is also likely that their effectiveness will be limited. It is doubtful that telephones (not to mention the National Geodetic Survey) will still be around in the year 11,996 AD.

²⁵ Ward H. Goodenough, "Communicating 10,000 Years into the Future," *Human Organization*, 58, no. 3 (1999), 222. ²⁶ Abraham Weitzberg, *Building on Existing Institutions to Perpetuate Knowledge of Waste Repositories*, (Columbus: Office of Nuclear Waste Isolation, Battelle Memorial Institute, 1982), 1. ²⁷ Ibid, 2.

2. Performance assessment of the disposal facility must be based on the assessment of probabilities. The consequences of a given scenario must not only be calculated but the likelihood of that scenario must be assessed. (40 CFR 191.13)²⁸

This provision requires that the WIPP and HITF panels determine the specific potential risks to the safety of the repository, as well as the probability of the specific risk, so that they be considered and accommodated in the design process. Because of the projected geological stability of the region, the main risk associated with the repository is the risk of human intrusion.

3. The time period to be covered is 10,000 years (40 CFR 191.13a)²⁹

Ambitiously declared on behalf of a government which has itself only existed for 225 years, the figure represents the amount of time necessary for the radioactivity of the buried transuranic waste to decay to the level of naturally occurring radioactive ores.

4. Active institutional controls are considered effective for no more than 100 years after closure of the site. $(40 \text{ CFR } 191.14a)^{30}$

After this initial period of active guarding, only the passive controls (the warning markers and maps distributed to institutions) will remain. Since the site will be actively guarded until the year 2096, the marker design will be an ongoing process until this date. Thus we may assume that the WIPP marker panel will be merely the first in a series of similar projects.

Scenario Development: Predicting the Future

While adhering to these regulations, and keeping their imposed limitations in mind,, the WIPPcommissioned panels set to work in designing an effective long-term warning message. The first step in forming any communication is to know the audience and the context for the message.³¹ Since it was impossible for the design teams to know either of these factors, part of their methodology became envisioning future scenarios and forming working assumptions. From these scenarios and

²⁸ Goodenough, 222.

²⁹ Ibid.

³⁰ Ibid.

³¹ Kenneth E. Foote, "Object as Memory: The Material Foundations of Human Semiosis," *Semiotica*, 69-34 (1988), 248.

assumptions, a general foundation was constructed, on which the design teams could begin to envision the message recipient. These assumptions served as a stand-in for an actual, known message recipient. In most fields, this sort of activity would be considered "predicting the future," but the DOE, accustomed to performing risk-assessments, referred to it more casually, using titles such as "calculation of all combinations of events and processes (scenarios)."²² Correspondingly, the methodologies used for assessing "scenario probabilities" prove to be much more pragmatic than whimsical. In the study, attention was only granted to scenarios seeming probable, or scenarios representing a logical extension of present day conditions and technologies. The probabilities of scenarios were tested according to an evaluation matrix resembling that of sports competitions. (Figure 2) The "assessment system" prepared by the DOE even provides provisions for dealing with uncertainties. (Figure 3) However, the system did not exact provisions for random events, which would greatly alter a consistent logical march toward the future. In fact, the DOE went so far as to establish rules banning the discussion of such scenarios.

The panel was, for example, prohibited from considering the popular possibility that artificial intelligence or extraterrestrial life might replace human life on earth by the year 11,996 AD, or that a meteor could possibly strike the site. The impact of any of these "unexpected" scenarios would be formidable — so much so that they would negate the other delicately constructed future scenarios considered by the teams. However, since the likelihood of either occurrence was considered small, and because the linear logical probability of "random" or "unexpected" events cannot be accurately charted, theses discussions were blacklisted.

A report drafted by a Futures panel member briefly recounts the ground rules set forth by the DOE in regards to scenario development:

- 1. The repository is closed after twenty-five years of operation. (i.e. after twenty-five years of actively loading the facilities with barrels of waste.)
- 2. No consideration is given to deliberate, intentional intrusions.
- 3. Active control of WIPP is maintained for one hundred years after the site is closed.
- 4. Passive measures are the only warnings provided after the first one hundred years.
- 5. Radioactive materials decay at currently accepted half-lives.

³² R. V. Guzowski and M. M. Gruebel, ed., Background Information Presented to the Expert Panel on Inadvertent Human Intrusion into the Waste Isolation Pilot Plant. Albuquerque: Sandia National Laboratories, 1991, 1.

6. Extraordinary events such as collisions with objects from space, extraterrestrial visits, or negation of gravity do not occur.³³

Ironically, the blacklisted scenarios seem somewhat probable when listed within the rigid prose of a government document. Although given an infinite amount of time (or 10,000 years perhaps) the probability for even "extraordinary" events rises. Undoubtedly, the very acknowledgement of these extraordinary events in the DOE's instructions provokes suspicion that they are merely listed as liability clauses (or abnegations of responsibility) rather than actual improbabilities.

The simplest factor in predicting 10,000 years of future change seemed to be predicting the physical environment. Since the earth keeps records of its activities in its own ways — through the layering of geologic strata, the slow land-building of glacial activity, etc. — the DOE could chart the regions' past activities and propose likely trends for the future with a fair amount of anticipated accuracy. A report entitled *Background Information Presented to the Expert Panel on Inadvertent Intrusion into the Waste Isolation Pilot Plant* provides in-depth studies of the physical history of the WIPP region — from studies of rainfall patterns to geological activity to climate change.

Once again, future human activity is the acknowledged wildcard in the scenarios game. In a report compiled for the HITF, communication expert Percy Tannenbaum noted that "…critical to the task of defining a suitable message system structure is the assumed kind of human organism."³⁴ Givens suggests we design for the "current *Homo sapiens*, as now understood, rather than for a novel, yet unknown species of *Homo*. Because modern man has not evolved significantly beyond the 40,000 year old *Homo sapiens* physical pattern (Campbell, 1966), one can postulate that deeply fundamental psychological processes of attention, perception, problem-solving, and emotional responsitivity will be isomorphic in key respects to our own.³⁵

Indeed, 10,000 years is too brief a span of evolutionary time for major changes in the species to take place via natural causes. However, as Tannenbaum suggests, substantial man-made evolution may occur in a far briefer time span. Applied technology and/or genetic mutations may change the manner in which people of the future see. Citing the rapid technological development of this past century, which extended the capabilities of the human sense of sight through inventions such as the

³³ Pasqualetti, 6.

³⁴ Tannenbaum, 5.

electron microscope, Tannenbaum alludes to the possibility of a radical change in the way humans will perceive the world by the year 11,996 AD. In regards to the senses, however, he ultimately concludes that "...with such a wide range of realistic possibilities, the selection of any particular human scenario is nevertheless uncertain for planning purposes."⁴⁶ Sebeok, in his report for the HITF, bolsters Tannenbaum's conclusion that it is impossible to plan for the wide range of sensory changes possible. He notes that "...here on earth every species carries a different *Umwelt* or 'cognitive map' of its environment."⁴⁷ In fact, different species are equipped to see in varying types of visible light. A cat, for example, can see much further into the infrared part of the UV spectrum than a human because of a mirror-like layer of cells that rests behind the pupil (called the tapetum lucidum).⁴⁸ Even the slightest change in the way that humans perceive their world would require a large shift in communication strategies. Therefore, even if the DOE wanted to consider the possibility that in the year 11,996 AD they may be communicating with extraterrestrials or slightly altered humans rather than the modern human, it would be impossible to design for their unpredictable sensory capabilities or *Umwelt*. "Even if intelligent life beyond earth were to exist, the weight of evolution stresses the unlikelihood of the appearance of humanoid forms elsewhere in the universe."³⁹

Ultimately, those involved in developing the preliminary reports for the HITF agreed that the warning system should be designed with the perceptual and sensory capabilities of the contemporary human being in mind, as this would provide the best stand-in for the unknown recipient of 11,996 AD. In Tannenbaum's report, he discusses the "sensory preferences" of modern human beings.

The greater emphasis is by far on the visual modality...Tactile information is also more likely to be detected than auditory stimuli in limited contrast situations. Thus, while there are occasional exceptions to the dominance of visual and tactile senses, all indications are that these are the most suitable modalities to employ for both technological and recipient purposes.⁴⁰

He goes on to suggest that the warning system be constructed to appeal primarily to the visual senses, with tactile signs serving as background warnings. It would therefore be important that the site be

³⁵ Givens, 160.

³⁶ Tannenbaum, 5.

³⁷ Thomas A. Sebeok, *Communication Measures to Bridge Ten Millennia*, (Columbus: Office of Nuclear Waste Isolation, Battelle Memorial Institute, 1984), 18.

³⁸ Ibid, 9.

accessible to sunlight to enable vision (not a tall request considering the desert location of the WIPP) and to human physical contact for the transmission of tactile messages.

After the background information (on physical environment) was compiled, the Futures panel was called in to further address the wildcard of human activity. The members of this Futures panel were Martin Pasqualetti of Arizona State University, Gregory Benford of the University of California at Irvine, Corey Kirkwood of Arizona State University, and Harry Otway of Los Alamos National Laboratories.⁴¹ The team comprised a fairly homogenous bunch, primarily older white males, which they themselves perceived as a detriment to the project.⁴² Not surprisingly, the team also found the DOE's rules confining — particularly the 10,000 years number, which they perceived as arbitrary and inadequate.⁴³ Another deficiency, as noted by Panel member Pasqualetti was that "a no-marker strategy was unacceptable."4 Indeed, both of these provisions were part of the enabling legislature responsible for initiating the marker design project, and thus could not be challenged or reversed during the design process. Although at least one Markers Panel member advocated a no-marker strategy, suggesting that a marker would only draw attention to the site and promote intrusion. However, the majority of the Markers Panel members, the DOE, and the enabling legislature disagreed. These team members ultimately felt that it was positive to attract attention to the site — that our primary responsibility is actually to bring attention to the site and the hazards posed by its presence. One panel member even suggested the construction of a museum on top of the interred repository, which would educate future generations on the dangers of nuclear waste.45 It was generally conceded that it was acceptable to attract attention to the site, as long as this attention did not lead to digging.

The Futures Panel sought to find out who might dig at the site, why they might dig, and how this digging could be prevented. They formed worst-case scenarios — ones that would have to be averted through the designs of the Markers Panel. First they identified seven categories of change that would heighten the probability of digging in the vicinity of the WIPP plant:

³⁹ Ibid, 18.

⁴⁴ Ibid.

⁴⁰ Tannenbaum, 17.

⁴¹ Pasqualetti, notes.

⁴² Ibid.

⁴³ Ibid.

⁴⁵ Tannenbaum, 19.

- 1. "Increased availability of water" (enabling people to live in the region)
- 2. "Population growth" (forcing people to move into the region)
- 3. "Unstable political control. Changes in political control, particularly at the national level, could complicate record keeping, confuse political will and responsibility, cloud institutional memory and challenge the stability of language." (periods of political unrest often results in the destruction of records, and would challenge the safekeeping of the WIPP site, as power shifted from one group to another)
- 4. "Lost knowledge." (of the location and/or dangers of the site)
- 5. "Resource development. Over a period of 10,000 years virtually any substance could become an economically valuable resource. This is true even of materials we now consider waste." (leading to escalated extraction activity)
- 6. "Changes in communication." (jeopardizing record keeping and marker effectiveness)
- 7. "Adjustment in the management of the facilities." (if resources were needed elsewhere, the active or passive controls over the site has cease entirely, leading to the risk of intrusion)⁴⁶

Given these risks, the Futures panel attempted to synthesize them into "a small and accurate group

of scenarios of future events."47 The team then developed five scenarios, regarding them with varying

levels of skepticism in terms of their actual probability.48

The first scenario, called "USA Forever," was deemed too improbable to warrant lengthy

refinement. Within this scenario, the United States would continue to develop within its existing

political, cultural, and socioeconomic structure."49 Institutional knowledge of the location and dangers

associated with the site would be retained through US institutions and a large risk of intrusion would not

be posed.

Under the "Mole Miner Scenario," technological advancements continue to take place, amidst social and political turmoil. This society would therefore be technologically advanced enough to intrude upon the site, but not advanced or organized enough to control the resulting radioactive threat.³⁰ Benford, the panel member who crafted this scenario (and who found that his contribution to the project was "much like writing a story" took inspiration from the "uneven progress" of technology in the Middle Ages.⁵¹ While China was actively developing items such as paper and gunpowder, Western Europe's focus had shifted away from materials innovation and invention and into the church.⁵² To illustrate an example of his scenario, Benford proposed the "smart mole." This device would tunnel through the earth, unmanned, in search of resources. (Figure 4) This type of technology would be

⁵⁰ Ibid.

⁴⁶ Pasqualetti, 4.

⁴⁷ Ibid, 14

 ⁴⁸ All scenarios, in their original form can be read in G. Benford, C. W. Kirkwood, H. Otway, and M.J. Pasqualetti, *Ten Thousand Years of Solitude?*, (Los Alamos, New Mexico: Los Alamos National Laboratory, 1991).
⁴⁹ Pasqualetti, 8.

⁵¹ Benford, 40.

especially threatening to the WIPP repository, as it would enter the site from a vulnerable vantage point: underground, bypassing all surface markers. Once the holes were bored, radioactive isotopes could escape through the new tunnel and enter the groundwater supply. Even if institutional knowledge of the dangers of nuclear waste were retained over 10,000 years (which was deemed unlikely by the panels), no one would know about this type of intrusion. Benford also notes that any technological innovations could have a similar impact.

The third scenario, aptly titled the "Doom and Gloom Scenario," envisions environmental disaster in the form of global warming, epidemics, loss of biodiversity, and loss of arable land. This sort of environmental crisis would force people to search for resources wherever possible, which might mean drilling for ground water near the WIPP repository.

The "Seesaw Scenario" begins very similarly to the "Doom and Gloom Scenario," but with a plot twist. After hundreds of years of decline and recession due to environmental catastrophe, society begins to rebuild itself. Agriculturally based communities begin cropping up in the area formally known as New Mexico. Environmental disruption has caused a tilt in the weather patterns of the region, causing more rainfall and thus making agriculture possible in the area which was formally desert. Political instabilities in the time remembered as the "Late Oil Age" prevented all of the oil in the region from being used. Antique maps indicate that vast amounts of oil had been acquired in the area formally known as Northwestern Texas. Prospecting for oil moves westward, ultimately arriving at the WIPP site. A dialogue ensues regarding the unintelligible markers left on the site.

"Perhaps they left it here to tell us that there's oil down below." "Maybe there is danger. We should consult the scholars to see if they know anything about this." "Ah, you know these old artifacts — all rusted junk. Forget them! Let's drill and see if there's oil..."³³

The final scenario, dubbed "The Free State of Chihuahua," is based on the possibility of future political upheaval. The stability of the US and Mexico have been affected by perceived inequities in political representation near the border area. Both the US and Mexico end up splintering into smaller,

⁵² Ibid.

⁵³ Ibid, 42.

self-governing states. Within the Free State of Chihuahua, one of these smaller states located just north of the Mexican border, families loyal to one of the other newly independent states are slowly escorted out of the country by guards. These guards are ordered to carry out a scorched earth policy, destroying all of the infrastructure of the former US. As a result, the Free State becomes somewhat of a scavenger society, "recovering, and reusing all available technical artifacts from earlier time." Arriving at the WIPP site, the Free State's "resource archaeologists" decide to take the marker material for building supplies and proceed into the repository to see what other materials reside below. Upon breaking into the site, the long sealed heat of radioactive decay forces ground water and molten salt upwards, forming a radioactive creek that combines with the water supply.

Aside from these five basic scenarios, the team mentioned the possibility that the site is equally likely to be breached by archeologists of the future or museums looking for new historical acquisitions as it is to be breached by casual vandals.

Although these scenarios are by no means comprehensive, they were considered to be the most likely occurrences. Pasqualetti notes that "the odds of an inadvertent intrusion will be influenced by how accurately we predict the future and how successfully we incorporate these predictions into our warnings."³⁴ In order to ensure that the message would be passed along to the Markers Panels, the Futures Panel organized their conclusions into a series of recommendations that would guide the design teams in their process of designing for these scenarios.

The Futures Panel left the Markers design teams with three official recommendations, naming these recommendations "Landscapes of Reclamation," "Landscapes of Repulsion," and "Landscapes of Illusion." The first option, Landscapes of Reclamation, "directly addresses one of the most fundamental uncertainties about effective warning strategies; that is, whether to make them blatant or subtle."⁵⁵ Landscapes of Reclamation suggests that the site be left completely unmarked — that the land above the interment site be slowly reclaimed by the desert landscape. The Futures Panel worried that attracting attention (and people) to the site would increase the likelihood of development and drilling on the site and concluded that the best way to prevent intrusion would be to leave it unmarked. Pasqualetti posits a different question in regards to whether to mark: "Would marking the site increase the chance of willful

⁵⁴ Pasqualetti, 12.

⁵⁵ Ibid, 24.

intrusions more than not marking the site would increase the chances of inadvertent intrusion?" Despite its logic, Landscapes of Reclamation was not an option for the Markers Panel, given that the enabling legislature required that markers be erected.

Landscapes of Repulsion, the second recommendation option "relies on intentionally odious and foreboding construction, erected both to symbolize danger and to deter intrusion."⁵⁶ The manner in which the area was marked would communicate "danger" on a visceral level.

The final proposed strategy, Landscapes of Illusion, would use the advantage of disguise inherent in Landscape of Reclamation, but would also meet the criteria that a marker be constructed. It also illustrates a level of skepticism on the part of the panel concerning our ability to communicate to the distant future — even through nonverbal or purely visceral markers. Landscapes of Illusion would employ a "soft" surface marker — one that would completely erode in a few centuries — made out of concrete or sandstone. This type of marker would cover the short term possibilities of intrusion, actively communicating "danger" to the near-future — the group most likely to understand the communications, as well as the most "at-risk" group, since they would probably remember that the site exists, empting exploration. The Futures Panel hoped that the "soft" marker would disintegrate at a rate proportional to that of the disintegration of memory of the site, so that after a set period of time, no record of the site would exists at all. However, Pasqualetti notes, "the public would not be without protection."³⁷ Records of the site would be linked to activities and institutions that might threaten it (such as mining and drilling,) however, this safeguard presumes that we will be able to predict all future motives for digging and that present institutions related to these activities will persist far into the future.

The second, more plausible safeguard would reside just below the surface in a spherical array, providing 360 degrees of protection underground. This recommendation, well suited to cope with the Mole-Miner Scenario, would employ the following to communicate with technological devices:

⁻ Acoustic markers, which would be easily detected by acoustic probes

⁻ Magnetic markers, providing a strong, single dipole located at the center of the repository

⁻ Radioactive markers. Provided that future generations retain knowledge of the hazards of radioactivity, small samples of radioactive isotopes could be left around the site and just below

⁵⁶ Ibid,13.

⁵⁷ Ibid.

the surface to warn of the larger radioactive hazard interred underground. The radiation given off by the samples would be "weaker than a radium watch, yet of long half-life."³⁸

However, despite the effort invested in developing these scenarios and recommendations, Futures Panel members later complained that their research and findings were largely overlooked in the markerdesign process. Although the stated purpose of the panel's activities was to inform the designs of the Markers Panel, the recommendations of the Futures Panel were prevented from being incorporated into the final design.³⁹ Since many of the members of both panels worked in the same fields of research, many being colleagues, the members of the Futures Panel were essentially able to sit on the sidelines and watch the process of the Markers Panel. They noticed that their recommendations regarding a nomarkers strategy were programmatically blocked from the discussions.

Markers vs. No-Markers vs. Soft-Markers

Two main lines of logic fueled the Futures Panel's overwhelming support of the no-marker/softmarker strategy. The first reason reflects the suspicion that the markers would provoke curiosity, regardless of whether people of the future comprehended the dangers that these markers represented. The second argument relates to the perceived inability to communicate the concepts of "nuclear" and "radioactive" to future generation. All of the panel members, as well as later commentators on the WIPP design project agreed to the likelihood that future generations will have found an alternate source of energy.⁴⁰ If this assumption is correct, the dangers of radioactivity will not be common knowledge as it is presently. All knowledge of nuclear waste and the dangers of radioactivity could perish rather quickly from both popular and institutional memory as nuclear energy fades into obsolescence. In this event, warning against "radiation" would be commiserate to warning against an unknown curse, another intangible threat.

However, some linguists and semioticians have argued that "meaning" is directly rooted in objects and that our communication systems rely on their material foundation. According to Kenneth E. Foote, an early Advocate of the application of semiotics to deep time design,

⁵⁸ Ibid, 14.

⁵⁹ Ibid.

⁶⁰ Excluding one nuclear industry representative, see W. B Mann, "Identification of Nuclear Waste Sites over Ten Millennia," *Nuclear and Chemical Waste Management*, 6, no. 1 (1986): 97.

Whereas energy transmitted verbally and even nonverbally dissipate rapidly, material artifacts have durability. They can be used over and over again in a variety of situations; in this way, they can connect series of interactions through time and space. Objects might be seen as an aid to memory, as a resource helping to assure continuity in communication.⁶¹

Foote refers to this phenomenon as "material expression" — the concept that meaning doesn't simply exist or persist independently, but that it depends on actual physical "reminders." According to his view, the concept of nuclear waste has little chance of survival without being firmly rooted in material expression. In this context, a marker would serve as an aid to memory — a material anchor to which the notion of "nuclear" would be attached, remaining part of the vocabulary in a culture that would otherwise have no reason to retain the concept. The marker itself would function to provoke a continuing cycle of questions and answers concerning the purpose of the marker and then the nature of the interred danger. This discussion would keep the concepts "alive." Object-based communication is well suited for deep time messages since "other resources require frequent reproduction for communication to occur..."^a 245 The continued reproduction/repetition of the original meaning transmitted by the object is however dependent on human interaction — i.e. perpetual human curiosity. If the region occupied by the marker were to be abandoned for a few generations, the chain of communication might be broken — the meaning of the place might be lost. Even still, creating a permanent marker remains one of the most promising strategies to aid in keeping words like 'nuclear' and 'radioactivity' in the collective memory.

Scenarios Created by the Markers Panels

This sort of logic presumably appealed to the Markers Panels who, in the end, developed several possible marker designs, all primarily object-based and communicating through material means. Unexpectedly, the Markers Panels also developed additional scenarios. Because it is unclear whether the development of these new scenarios was intended to augment or to fully replace the scenarios developed by the Futures Panel, it is difficult to determine whether this action undermined the cumulative nature of the design process. Maureen Kaplan, of Markers panel A, attests that although the panels did read the scenarios, they informed the teams understanding of the challenge in a more general sense.

⁶¹ Foote, 245.

We all read them. We thought about them. We figured we had to be ready for anything. It was about then that I realized that it didn't matter that we couldn't see into the future-no one can. But the people of the future would be looking backward, the same way we look backward when we visit or look at some piece of antiquity. Imhotep would have no concept of me, my life, my language, or religion. Yet I had colleagues who could read the Pyramid Texts off the walls of Unias' pyramid to me. So the task becomes "what made it possible for us to understand, and how do we include that in the marker system design?"⁶³

Nevertheless, in terms of the risks presented by the scenarios, the Markers Panels' scenarios do not necessarily deny or conflict with the risks inherent in the Future Panel's scenarios. Though the scenarios compiled by the Markers Panel seem to all have happy endings, each afforded by the successful use of warning markers. Goodenough, a member of Marker Team B, briefly outlines the following scenarios in his report.

1. Human existence has been reduced to what can be supported by a metal-using technology like that of early medieval Europe. The probability of an intrusion into the WIPP site is relatively low. There is little need for a marking system. One that is awesome and scary, like the one we came up recommending, might invite use as a place of assembly for religious purposes, but it would not invite intrusion 2,000 feet down, given the low level of technology.

2. Human existence has continued with regional ups and downs at the present level of technological sophistication, at least, if not a higher one. The WIPP site is marginal for human habitation because of cycles of climatic change between desert and grassland. People who encounter the site are likely to be relatively unsophisticated, being herders or resource prospectors. If the site is marked in a massive and awesome way, word is likely to reach officials, scholars and scientists. Its massive scale will then draw scholars and scientists to study it, decipher the message inscribed there, and thus acquaint them with the dangerous nature of what is deposited there.

3. Human existence goes through a period of global catastrophe and is reduced to a state bordering on illiteracy and stone age technology and then redevelops new technological sophistication, new literacy, and new science. The probability that people will then be able to decipher and read the messages inscribed there will be low, unless the inscriptions themselves provide a key to their interpretation. By having the same messages arranged in a way that shows them to be parallel statements in different languages and scripts, the site design can provide an equivalent to a Rosetta stone and increase the probability of successful decipherment.⁶⁴

⁶² Ibid.

⁶³ Maureen Kaplan, interview by author, 10 September 2005, Lexington, MA, email correspondence.

⁶⁴ Goodenough, 4.

These scenarios are clearly less concerned with illustrating possible risk than the scenarios posed by the Futures Panel. In fact, they serve an opposite function — they illustrate the potential success of marker systems. Whereas the Futures Panel used the scenarios methodology as a tool to illustrate possible risks — against which preventative design measures could be taken — the scenarios offered by Goodenough seem to only champion the warning marker. Additionally, all of the scenarios listed in Goodenough's report fail to assume an escalation in technological development or the possibility of drilling activity. It is therefore dubious whether these narratives might even be considered scenarios at all, considering that the intended role of the scenario-development has to identify possible risks. Nevertheless, these scenarios were undoubtedly utilized by the design teams to form their assumptions about the future and ultimately, in their design of the marker. Whether or not the "official" scenarios, developed by the Futures Panel were used to their full potential is unclear.

Marking Without Material

Aside from the no-marker strategy proposed by the Futures Panel (and presumably ignored by the Markers Panels), other alternatives to a material marker were suggested. These suggestions are offered as "an addition to" or "to augment" a material marker. Foote, who strongly supports the use of material expression as an aid to memory, also mentions the historical effectiveness of oral tradition in propagating long-lived communications. He writes, "Objects are, of course, not the only means of sustaining the continuity, as is evident from the study of oral tradition..."⁶⁵ 245 In fact, Sebeok, in one of the first reports commissioned by the HITF, suggested that oral tradition be used to "mark" the site. Noticing the enduring potency of myth, he quotes Harrison's classic survey of *Pandora's Box*: "There is a strange fascination about a mythological character that has retained its vitality up to our own day..."⁶⁶ In order to diffuse information throughout society in a manner that will persist through coming millennia, Sebeok suggests using folkloristic devices as a supplementary aid in warning against nuclear waste.⁶⁷ By creating a "ritual-and-legend" which would be transmitted orally from generation to generation, the DOE would propagate superstition — picking up where scientific knowledge of radiation tapers out. The actual "truth" about the site would be entrusted to an "atomic priesthood,"

 ⁶⁵ Foote, 245.
⁶⁶ Harrison as quoted in Sebeok, 22.
⁶⁷ Sebeok, 24.

responsible for perpetuating the legend and selecting their successors. However, Sebeok acknowledged that the procedure of creating an "artificial" myth is unclear. "Folklore specialists consulted have advised that they know of no precedent, nor could they think of a parallel situation, except the well-known, but ineffectual, curses associated with burial sites (pyramids) of some Egyptian Pharaohs, e.g., of the 19th dynasty, which did not deter greedy grave-robbers from digging for "hidden treasure."⁶⁶ Furthermore, Benford argues that while folk memory is long-lived, it often becomes exceedingly inaccurate over time from narrative embellishments.

Modern Australian aborigines recall landmarks that were flooded since the last ice age, eight thousand years ago; divers verified their existence. But much of this information is cloudy, what does the mythical beast called the "bunyip" correspond to?"

Ultimately, however, since the "enabling legislature" of the WIPP did not enact provisions for an approach based on oral tradition, work in this area ceased at these hypotheses. However, at this time, ninety-one years still remain to plan for the point when "active controls" are to be replaced by their passive counterparts. The oral tradition strategy may be further developed in the future.

The Use of Multiple Message Levels for Redundancy

In the end, whatever dissent remained between panel members, one aspect was universally agreed upon — that the warning message should be communicated/stated in as many ways as possible. Sebeok, not expecting to fully rely on the atomic priesthood strategy to protect future generations, acknowledges that "any form of energy propagation can, in fact, be exploited for the purposes of message transmission."⁷⁰ The more redundancy built into the communication system, the more effective it will be.⁷¹ The marker design should strive to communicate through every technological means available — from oral tradition to physical markers to magnetic signals to malodorous smells.

As previously mentioned, David Givens suggests that redundancy should be achieved not only through the medium, but also through the "level" of the message sent. Gives, an anthropologist, outlined four basic levels of communication to which the designs should appeal:

⁶⁸ Ibid.

⁶⁹ Benford, 8.

⁷⁰ Sebeok, 7.

⁷¹ Ibid, 16

Level 1: Simple ("Humans have made this, its important")

Level 2: Cautionary ("Trouble!")

Level 3: Basic ("This is old and technical")

Level 4: Detailed ("These radioactive are here — leave them alone until 11,996 AD or...)ⁿ

In general, each level communicates on a slightly more detailed level. However, the levels of communications are intended to function as a system — intended to solicit very specific responses from potential intruders. Realizing the first level (that the marker is man-made) is essential to unlocking the meaning of the other levels, as it indicates that there may be a message consciously embedded in the site.⁷⁷ An intruder, realizing the Level 1 and possibly Level 2 messages, will either be inclined to leave or to seek expert advise in decoding the other messages. This expert will presumably be able to read the Level 3 or Level 4 messages and would advise against further development of the site.

Employing a markers system that communicates on various levels and by various means possesses the advantage of durability over the construction of a single, monolithic message. Even if most of the structure of the marker is destroyed, along with the more sophisticated messages, the Level 1 signs would still persist.⁷⁴ The report publishes by the Markers teams explicitly states that "everything on the site is conceived of as a part of the message communication...from the very size of the whole site marking down to the design of protected inscribed reading walls and the shapes of materials and their joints."⁷⁵ Thus, the material entirety of the site, as well as the integrated levels of messages should function together as an integrated whole, stating one unified message: "Keep Out!"

⁷² As recounted by Benford, 66

⁷³ Benford, 66.

⁷⁴ Givens, 172.

⁷⁵ Sandia National Laboratories. Expert Judgment on Markers to Deter Inadvertent Human Intrusion into the Waste Isolation Pilot Plant, (Washington D.C.: Division of High-Level Waste Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, 1992), 2.1.

Chapter Three: Influences: Establishing Precedence

To ensure the effectiveness of the markers, the design teams looked to objects and research that would answer the question — "How does form communicate independent of language?" The fields which the design teams sought influence, can be broken down into three basic categories — archeological influences, semiotics studies, and communication design influences. Archeological influences, the study of ancient artifacts, provided insight into strategies for material conservation and long-term communication effectiveness. The semiotic studies used the same objects to analyze the mechanics of how these objects communicate. And the study of communication design enabled the teams to access a well-honed body of knowledge on the topics of organization, legibility, and presentation. The research conducted by the design teams helped them establish precedence in a design project that held no precedents.

In this section I will differentiate between direct influences, which were cited specifically by the design teams, and indirect influences, which are pertinent to the project, but not explicitly mentioned in the design team's reports. Many of these indirect influences are from standard, influential texts with which the team members would have been familiar.

Denotative vs. Connotative Messages

In examining the texts and objects that influenced the design teams, some patterns become apparent. For example, the texts cited treat small-scale and large-scale messages differently. In general, small-scale messages — such as iconography, pictograms, text, etc. — are thought to communicate in a "denotative" fashion rather than a "connotative" fashion. These types of messages engage the viewer's interpretative faculties and encourage a "reading" of the encoded message. In this sort of communication, the viewer is compelled to focus on and analyze the details of the communication rather than the total impact of the marker — i.e. the message is dissected from the physical marker. Conversely, large-scale messages communicate in a connotative manner. Largescale, connotative messages are formed and affected by factors such as size, placement, and gestalt and are discussed in relation to installation art, much public art, and environmental graphic design. This type of message is intended to be 'felt' rather than 'read.' A communication emerges via the cumulative effect of an object and how it relates to its environment — rather than by analyzing select parts of the total structure.

Another pattern that emerged from the referenced texts was the importance of redundancy in creating tangible, long-lasting messages. The use of redundancy and multiples may aid in the reception of small-scale communications, while contributing to the longevity of large-scale messages. The Assyrian stone tablets mentioned in Chapter 1 provide an example of how redundancy can be used in deciphering small-scale messages.¹⁶ The overlap of the symbols appearing on the tablets, as well as the patterns emerging from them as a group help later scholars interpret their meaning. Since "...several components within a given marking design, a number of items within each component, and crossreferencing to link components..." were used, meaning can be extracted even though the symbols used were not initially understood.⁷⁷ The ability to read these symbols comes from the interconnected, selfdeciphering web created by their overlap, not by the intrinsic communicative properties of the characters themselves.

In terms of large-scale communications, Goodenough cites Stonehenge as an example where a multiples strategy contributed to the longevity of the monument. He notes that although a third of the stones have been removed from the site, the quantity of stones used ensures that enough remain to 'reconstruct' the original design.¹⁸ If the designers of Stonehenge had employed a single, monolithic approach, wherein only one stone was used, it would almost surely be gone today. The use of multiple stones, which creates a sense of environment versus a sense of object, promotes the longevity of a site. Stonehenge remains intact today largely due to the multiples strategy employed in its construction.

Multiples and the Migration of Meaning

Chebat, in his discussion of Lacan's theory of vacillation, also provides support for a "multiples" strategy. Although Chebat applies Lacan's theory to the branding of consumer products, rather than the study of archeological artifacts, it nevertheless provides further insight into the way that multiples can preserve meaning. Chebat speaks of a process in which "the signifier [the object] ceases to fulfill its function of creating meaning and moves on, leaving its place to another signifier."⁷⁹ Chebat uses this

⁷⁶ Benford, 10. ⁷⁷ Goodenough, 224.

⁷⁸ Ibid.

⁷⁹ Jean-Charles Chebat and June Marchand, "The Quest for the Lost Object," Semiotic Inquiry, 18, no. 3 (1998), 184.

theory to explain how a brand comes to replace the object in advertising. It is conceivable that in the course of 10,000 years of change something similar could happen to the meaning embedded in the warning marker. The meaning (the warning) could possibly migrate from the object originally signifying danger to a secondary object or entity. This may occur as a result of the removal of the original signifier from the site. Or, that an object or marker could, after years of successfully communicating meaning, begin to assume a new significance to the community that surrounds it. For example, the original "warning" meaning might be replaced as the marker gained a religious significance. Although the original meaning may have been drained from the signifier it could, in accordance with Lacan's theory, migrate and adhere to a second nearby or related object. The basic concept is that meaning migrates — it can be transferred from one signifier to another by unexpected phenomenon. Because of this, redundancy in material expression may ensure that the migration of meaning is kept on-site. Increasing the amount of markers means increasing the likelihood that the site is forever marked as "significant." Thus, even if the most prominent meaning-bearing marker is removed (from its physical or conceptual context) the remaining markers may remind that 'meaning once existed here.' They may prevent meaning from being permanently disassociated with the site. Kaplan: Objects and Archaeology

Of course this discussion becomes increasingly abstract and hypothetical. Instead, most members of the design teams took an object-based approach, wherein they would gain design insight through the direct study of objects from the ancient world. Dr. Maureen Kaplan, member of Markers Team B, stresses archaeology's connection with deep time design research — "Archaeology is concerned with man-made monuments and information which have survived for long periods of time."⁵⁰ In reports published prior to the formation of the WIPP, Kaplan proposed that "…archaeology can provide a basis for designing a segment of the disposal system — the marking of the site to minimize future human interference."⁵¹

She begins her report with a simple the question — "To Mark or Not to Mark?"^{s2} Kaplan clarifies immediately that she advocates the former and continues by providing arguments that attest to the necessity of a physical marker. First and foremost, she says, "...the decision to mark the site reflects a

⁸⁰ Kaplan, 257.

⁸¹ Ibid.

sense of social responsibility."⁸³ Leaving the site unmarked, she implies, is therefore an abnegation of our collective responsibility. Furthermore, "hiding" the site in secrecy will not prevent it from being unearthed. She believes that since it is impossible to determine what will and will not be a remote location in the distant future, it is unrealistic to assume that the repository will still be in the middle of an unpopulated desert in the year 11,996 AD.⁸⁴ Furthermore, present day archaeological investigations "have covered nearly all of the globe." With the expected rise in technological sophistication, we will not be able to keep any interred secrets from future generations.

In regards to exploring oral tradition strategies rather than a markers strategy, Kaplan outlines three potential difficulties. She primarily believes that enacting a strategy of oral tradition is not a substitute for creating a physical marker, and thus we will still be defaulting on our responsibility to future generations to mark the site.⁴⁵ Kaplan also questions the effectiveness of oral tradition in transmitting detailed information to future generations. The myths we now know today, even those that are associated with oral tradition (she cites *The Iliad* and *The Odyssey* as examples), have only survived because they were written down at one point in time.⁴⁶ "Once they were written out, it was the literary tradition, not the oral, which preserved Homer's epics for our time.³⁷ Also, since oral tradition is such an "inherently vibrant and mutable phenomenon" that it is not the ideal medium for transmitting the specific information necessary to mark the exact location and hazards of the repository site.⁴⁸

Kaplan's report primarily focuses on how objects from the past may be used to design communications for the future. Her methodology confined her investigation to objects at least 1,000 years old and deriving from the widest range of cultures possible.³⁹ Kaplan first outlines the negative and positive qualities of the artifacts in terms of long-term communication and then suggests how these lessons might be applied to the development of a deep time nuclear warning system.

Kaplan begins her inquiry of ancient markers by examining the pyramids at Giza. Dating from the 4th Dynasty (from about 2575-2465 BC) these structures have already survived for almost half of the

⁸² Ibid.

- ⁸⁴ Ibid.
- ⁸⁵ Ibid, 258 ⁸⁶ Ibid.
- ⁸⁷ Ibid.
- ⁸⁸ Ibid.

⁸³ Ibid.

10,000-year time span required by the WIPP legislature. (Figure 5) The pyramids are unique in the amount of information that has been retained about them, having survived many eras of political change and vandalism. Pharaohs Khufu, Khafre, and Menkaure built them as tombs for transferring themselves to the afterlife. We today know the purpose of the pyramids, who built them, and their original condition which comes to our generation from a variety of sources.[®] Early historians such as Herodotus (Greek 5th century BC) and Pliny the Elder (Roman, 1st century AD) provide accurate accounts. However, even without their written contributions, the information would have been passed down by way of inscriptions from inside of sarcophagi and on the walls of the burial chambers. The Egyptians inscribed all of this information in stone. This is helpful in guiding the WIPP's project, according to Kaplan. Though, "on the negative side, the pyramids have survived because of their massive size."91 Even after officially being declared quarries around the year 1200 AD, there is "still sufficient material left to make a strong impression on any visitor."²² This is largely because each pyramid was built to mark a single point — the interred (or in later designs hidden) sarcophagus. Although the pyramids have proven that their geometry and construction can endure the abuses of time and of desert, it would be impractical to build a pyramid the size of the WIPP repository — which would be at least 14 times the size of the largest pyramid at Giza. Kaplan also notes that marking the large area with a smaller pyramid would inadequately define the boundaries of the hazardous area.

In terms of human interference, there is also the problem that looters often entered the pyramids from below. The pharaoh and his treasure were buried underneath the pyramid prior to the "false tombs" innovation appearing in the 4th Dynasty.³⁹ (Figure 6) However, Kaplan notes that this may not be an issue since the pyramids were broken into because robbers knew that they would find treasure. The WIPP site would lack this incentive.

The tombs were known to have valuable contents, sufficiently valuable to be worth the risk of getting caught. This will not be the case with a disposal site, which will offer little incentive to disregard the warnings.⁹⁴

⁸⁹ Ibid, 258.

⁹⁰ Ibid.

⁹¹ Ibid.

⁹² Ibid.

⁹³ Anthony F. Janson, *History of Art*, 6th Edition, (New Jersey: Prentice Hall, 2004), 54.
But what if there is no risk of getting caught in the future? If no governing authority exists, then little incentive would be needed to breach the site.

The second ancient marker investigated by Kaplan was Stonehenge, "...the magnificent monument standing on the Salisbury Plain..."⁹⁵ (Figure 7) Kaplan first notes that what we know today as Stonehenge was actually a cumulative building effort over millennia. The earliest features including the henge (the ditch) and bank which encircle the megaliths — date to about 2700-2500 BC while work on the monument was not completed until 1900 BC. In addition to the henge and the larger stones are 56 Aubrey holes, which follow the circumference of the inner bank, and an inner ring of smaller stones lacking lintels. Stonehenge is remarkable in that it has managed to survive its nearly 5,000 years in an intense environmental and political climate. It has survived "invasions (in 55 BC, 40 AD, and 1066 AD), the Internecine War of the Roses (1455-1405 AD) and the two World Wars."

As mentioned earlier, Stonehenge is also an important example because of its successful implementation of redundancy — although some of the original stones are missing or have fallen, it is easy to reconstruct the design from the remaining pieces. This use of multiples also has a spacebinding function. Unlike the pyramids, where space is demarcated by mass alone, the megaliths comprising Stonehenge function much like a loose fence — marking space with alternating gaps in material mass. Spacing and ratio are important in this sort of space demarcation strategy. Kaplan notes, "the height of the largest stones in Stonehenge can also provide an estimate of the largest-sized component we might want in the marking system."⁹⁷ Although she does not expand on this point, it can be assumed that she admires Stonehenge's design effectiveness as a boundary marker in spite of its relative economy of materials. The stones are large enough to be minimally affected by the forces of erosion, although they do not fill the entire perimeter of the space.

However, "unlike the pyramids, there is no contemporary written information associated with Stonehenge," severely limiting our understanding of the monument and its purpose.³⁸ The names of its builders and designers have also been lost to history. Especially puzzling is the fact that it possesses features unlike any of the other stone rings found in the British Isles - raising questions about why it

⁹⁴ Kaplan, 259. ⁹⁵ Ibid.

⁹⁶ Ibid.

⁹⁷ Ibid.

was built (did it share a similar purpose to the other rings?, why the variance in design?) The alignment and patterning of the stones comprising the circumference parallels the ancient moonrise cycle.⁹⁹ Unfortunately, oral tradition is also unhelpful in piecing together these mysteries. Kaplan writes, ..."Although it was recognized that some stones were imported, Geoffrey of Monmouth (about 1136 AD) tells of Merlin saying 'Send for the Giant's Ring in Ireland', when the stones actually originated in Wales."¹⁰⁰ Therefore, while the manner in which the materials demarcate space may surpass the marking practicality of the pyramids, Stonehenge's message of purpose has been lost. And while the monument employs redundancy in material expression through the use of multiples, it lacks the redundancy in communication strategies that enable us to "read" the pyramids.

Kaplan, moving onto her discussion of the Acropolis notes that "the situation is very different here" — a multitude of texts detailing the purpose, origin, and architectural theories behind the monument survive. Kaplan explains that Pericles (died 429 BC) was primarily responsible for rebuilding the Acropolis after peace was made with Persia. Historic documents relay the names of the architects and sculptors employed and even the source of funding for the project (which was largely amassed from the sale of old buildings, grants from the Athens Treasury, and from private donations).¹⁰¹ "Even the annual building accounts for the Parthenon and the Propylaia were publicly displayed on the Acropolis."102 Historical texts have also stated that the Parthenon was intended for religious purposes. However, even without this textual knowledge, the later use of the Parthenon as a Byzantine church and later a mosque, would have alluded to its original purpose.

Kaplan remarks that the Acropolis is an excellent example to behold, since it "has suffered far more at the hands of man than from the ravages of nature."¹⁰³ In addition to the destruction caused by warfare, pollution has become an increasing problem. At its current intensity acid rain has begun to slowly destroy many of the marble and limestone sculptures of the Acropolis.¹⁰⁴ To prevent further

⁹⁸ Ibid.

⁹⁹ Janson, 46

¹⁰⁰ Kaplan, 259.

¹⁰¹ Ibid, 260. ¹⁰² Ibid.

¹⁰³ Ibid, 261.

¹⁰⁴ The Caryatids that can now be seen on the south porch of the Erechtheion, for example, are replacement figures - the originals lie protected inside of the Acropolis Museum. Since limestone is a calcacious stone, it is prone to this type of chemical erosion, unlike silicaceous rocks such as granite.

incremental damage, many of the original sculptures have been moved indoors to museums, and others undergo constant conservation and restoration work. ¹⁰⁵

Kaplan also discusses the Great Wall of China, a monument that has lasted for over 2,000 years commissioned by Qui Shi Huang Di in 221 BC and completed in 210 BC. "Construction methods differ along its length," depending on the local availability of materials. In the east, rubble was laid without mortar and piled with tamped earth, while in the west, silt was mixed into a slurry and poured between frames and then faced with stone.¹⁰⁶ (Figure 8) The later Ming period reinforced the construction, adding a granite foundation and facing the rubble or earthenware walls with brick or stone. The preservation efforts of a later generation has resulted in a cumulative building process, which has surely contributed to the longevity of the Great Wall. Which is fortunate, considering that the wall was built with such small components — brick, stone and rubble — which require continual repairs. In terms of the WIPP project, the important question that the Great Wall of China may answer is how its builders — in spite of having used non-permanent materials — ensured that their monument would be maintained for millennia to come? According to Kaplan, the answer lies in political factors, which would have been unanticipated by the Great Wall's builders. "The Great Wall received this care primarily because it served a protective purpose for the rulers of the country."¹⁰⁷ It was easy for the successive rulers of China to see the benefit of the Great Wall, as it protected from a contemporary, immediate, and concrete threat. Fortunately, as Kaplan notes, there is a symmetry here, as the WIPP's project "...will also serve a protective function."108 The WIPP marker protects from the invisible and abstract threat of nuclear waste. Kaplan suggests that "the Great Wall indicates the possibility that the marking system may be updated and repaired by future generations, should this be required."109

The final marker investigated in Kaplan's report provides an example of an unsuccessful marking strategy. The Serpent Mound, located in Ohio, consists of "an embankment of earth in the form of a

¹⁰⁵ A second valuable lesson in materials conservation has also been inadvertently (and unfortunately) proffered by Nicolas Balanos, a restorer of the early 1900's. In seeking to strengthen the iron bolts and girders which provide the supportive framework of the Porch of the Maidens, Balanos replaced them with steel counterparts. The problem with the steel, aside from the fact that it weakens over time, is that it expands — which has caused significant cracking in the marble, causing a danger of collapse in some areas. Kaplan notes that "…this should be a solemn warning to those who might propose technologically advanced materials which have not had the chance to undergo the test of

serpent in the act of uncoiling."¹¹⁰ The mound is comprised of two parts — the serpent itself and an oval-shaped mound near its mouth. (Figure 9) The core of its structure is made up of stone and clay which was then covered with earth. The problem with the Serpent Mound, according to Kaplan resides in the fact that "the serpent form meant something symbolic to its builders, but only means something literal to us."¹¹¹ Since the form of the snake is pictographic, we can identify the animal referenced, but not the greater significance that this creature might have held to the society which made it. The monument's readability also suffers from a lack of multiples — since it has no parallels in North America, it is impossible to study it in terms of a formal type, which often leads to the discovery of new information about the visual conventions and values of a culture. However, Kaplan warns, this is a place to be careful, as the WIPP repository may also be the only one of its kind. Somehow, redundancy must be incorporated into the design system of the WIPP since even pictographic images will lose their significance over time.

In her investigation, Kaplan found that the single most important measure in ensuring long-term communications is preserving the historical texts associated with the marker. Historical texts have been the most valuable source of information in deciphering the meanings of the pyramids. Although it is probable that the current world languages will be indecipherable to future generations, we should still leave behind historical texts, for if we do not "we remove the possibility of reconstructing the information at some future time."¹¹² Despite the importance of such texts, Kaplan does not deny the importance of the physical monument. She notes that sometimes, like in the case of the pyramids, the monuments are capable of carrying their own detailed messages independent of written documents. Even if the monuments become completely indecipherable, they serve the critical function of an index, pointing the way towards historical texts, which may otherwise be interpreted as fiction.

The study of ancient monuments has shown that language carries historic detail and logistical information more effectively than pictographic symbols. However, the combined use of pictures and text seems effective in carrying information over a long period of time. Kaplan concludes that archeological evidence indicates that the WIPP marking system should incorporate symbols, pictures, and languages to convey its message. The ancient world has also passed on important lessons

¹¹⁰ Ibid. ¹¹¹ Ibid. ¹¹² Ibid. concerning the durability of materials. Interestingly, the monuments that last are not the most technologically advanced, but those that are constructed out of natural materials. Materials such as earth or stone tend to last, while more "advanced" materials — due to their malleability and multiple functional uses — tend to be pillaged and reused. Metals, for example, are often recycled, since they are both desirable in times of warfare and easily melted and reshaped. Kaplan notes "The Parthenon once bore a set of bronze shields erected by Alexander and bearing an inscription by Nero." "We know of them only by the written records and the holes left by the mounting pins."¹¹³ Even the most durable materials, which would otherwise last hundreds of thousands of years, can be pillaged within decades if they can be easily reused.

The monuments investigated also provide insight into issues of placement and scale. Assuming that human eye-level and angle of vision remain consistent over the next 10,000 years, these issues can be considered and honed based on current parameters. Kaplan notes that it is important that the marker can be viewed as a whole with a single glance. If the elements comprising the marker are not perceived to be part of a whole, the boundaries demarked by the system will fail. She contrasts the successful examples of Stonehenge, the Acropolis, the pyramids, and the Serpent Mound with the "unsuccessful" example of Avebury. A stone circle similar to Stonehenge, but much larger, the components of Avebury cannot be experienced as a single unit, which hampers the viewer's understanding of the monument. (Figure 10) Due to the scale of the relatively small stones and the relatively large distance between them, "it is easy to stand in one part and not realize that the remaining section of the monument exists."¹¹⁴ Thus the consideration of issues such as placement, scale and component ratios may be just as important a consideration as what type of material to use.

Based on her observation of ancient monuments and the lessons that these monuments teach about the durability of deep time communication, Kaplan draws some conclusions on how the marker system should be designed. Not surprisingly, she borrows the basic form from Stonehenge — "its primary feature is a series of monoliths ringing the perimeter of the disposal site."¹¹⁵ Close attention should be given to how the viewer will physically experience the ring. They should be able to stand at one monolith and view all the others. The size of the monoliths should be roughly two times human height

¹¹³ Ibid.

¹¹⁴ Ibid, 263.

for maximum visibility. Kaplan notes that in general, monuments twice the size of human height and larger are usually left at their original site, whereas objects less that twice human height are removed and placed in a museum.¹¹⁶ And like the stones at Stonehenge, the surface markers should be made out of a singe block of material — which minimizes the material interfacing that invites corrosion. Each of the monoliths will be inscribed with parallel symbolic, pictographic and language-based communications, restating the dangers of the site in as many ways possible. Because identical messages are repeated on each megalith, a few stones can be lost over time without jeopardizing the effectiveness of the marker. Kaplan also suggests the use of a harder stone, like granite, since the calcaceous marbles and limestones of the ancient world are already becoming defaced by the relatively recent phenomenon of acid rain. Granite is hard, compact and of low intrinsic value, minimizing the likelihood it would be stolen. Furthermore, since granite is difficult to work, it is also difficult to deface (although more advanced stone-working tools may be developed in the next 10,000 years.) Many of the Egyptian wall reliefs are slowly being destroyed by salt inclusions — caused by lingering rainwater seeping into the picture surface. However, a smooth compact stone like granite, which lacks pitting, would resist such damages. She notes that further design measures can be taken to prevent water from lingering on the surface of the marker — such as tapering the megaliths slightly from the top to bottom to promote rainwater drainage. Wind erosion is another potent force to combat, especially in sandy desert regions. Kaplan notes that since the "...facade of the Treasury of Petra in Jordan is probably in better condition than other facades at the site because it is recessed into the cliff wall," that a raised "lip" around the surface of the marker inscription might be a good precaution. (Figure 11)

These guidelines apply to large-scale components of the marker system — however Kaplan also offers advice on developing effective small-scale messages. She divides messages into three categories: symbolic, pictorial, and semiotic/language. Kaplan discusses the possibility of the using the current uranium, trefoil radiation, or biohazard symbol in conjunction with the site markers. (Figure 12) She dismisses the uranium symbol immediately since it inadequately describes the hazard of nature of the interred wastes — which will include not only uranium, but also other radioactive

36

waste. The radiation symbol has "the properties of symmetry, regularity, and simplicity — making it a 'good' figure."¹¹⁷ This symbol also accurately describes the nature of the waste, making it a good option. The third symbol investigated, the biohazard symbol, is rejected on the grounds that it is misleading — while radioactive waste becomes less hazardous over time, toxic waste remains dangerous indefinitely. However, using a symbol as a warning strategy at all possesses a high chance of failure because it is not a 'natural' form. Kaplan quotes the American Institute of Graphic Arts (AIGA):

We are convinced that the effectiveness of symbols is strictly limited...They are much less effective when used to represent a process or activity...The use of symbols alone, without consideration for the verbal messages and all other signing, will only add to the confusion.¹¹⁸

However, Kaplan does not entirely dismiss the use of symbols as confusing or arbitrary. Since the trefoil symbol has "good gestalt" and three decades of use behind it to establish its context, it should be considered for use on the markers.

Pictures, unlike symbols are always made to resemble the objects and phenomenon to which they refer. This sort of realism, with visual simplicity for easy readability, contributes to a successful picture. Kaplan suggests that three different ideas can be expressed in picture form on the markers: 'do not dig', 'where the waste is buried', and 'consequences of disturbing the site.'¹¹⁹ For the 'do not dig' sign, Kaplan suggests that inspiration be taken from the Department of Transportation's (DOT) *Signs and Symbols* project which is used to create international travel signage.¹²⁰ According to Kaplan, this sort of sign would need only to show a person digging with a shovel crossed out by the characteristic red bar of the standard "no" symbol.¹²¹ Although the association of shovels with digging is fairly well connected today, this connection may be compromised over the span of 10,000 years, vitiating the icon's effectiveness. Still understanding the meaning of the sign may not require the viewer to recognize the specific tool doing the digging, but only to notice that the tool is displacing dirt. For the

¹¹⁷ Kaplan, 265.

¹²¹ Kaplan, 265.

¹¹⁶ Maureen F. Kaplan and Mel Adams "Using the Past to Protect the Future: Marking Nuclear Waste Disposal Sites," *Archaeology*, 39, September-October (1986), 54.

¹¹⁸ Ibid, 264.

¹¹⁹ Ibid, 265.

¹²⁰ More information on this topic is provided later in Chapter 4 of this paper.

'where the waste is buried' picture, she suggests using a simple map of the area where the ground line and markers will be readily apparent to the viewer, and which reveals that the unknown danger is below the ground. (Figure 13) It is important that accurate spatial relationships are maintained in such an illustration. Communicating the actual hazards of the site will be a bit more challenging, especially considering that the ill effects of nuclear waste are invisible and slow to manifest themselves. She references a pictograph created by the HITF, which poorly communicates the hazard of drilling (just what do those octopi forms represent?) but manages to successfully portray the risk of human illness. (Figure 14) The successful part of the drawing consists of the last two frames. The penultimate frame shows three human-like figures standing upright. All bear the symbol of contamination (which is shown rising out of the newly drilled hole in the ground like little spiders.) Only one seems to be adversely effected by the contamination. This unlucky figure, grasping his abdomen in the penultimate frame, is lying dead by the last frame.

Kaplan's final section discusses the notion of "levels" of communication, citing Givens as an influence. She proposes that one simple and one detailed message be inscribed into all of the markers, repeated in the six official languages of the United Nations which span several linguistic families — Indo-European, Sinitic, and Semitic. She cites the Rosetta Stone's use of multiple languages as an inspiration to this approach. The proposed simple message explains the danger of the site in 35 letters and 7 words: "Danger. Do not dig here. Radioactive wastes."¹²² Kaplan notes that it will be difficult to specify in such a brief message that surface activities are not dangerous, while deep activities pose a threat. The longer text extrapolates on prohibited activities:

This area is a disposal site for radioactive wastes. The area of the disposal site is ______ by ____ meters and is outlined by these markers. The radioactive waste is buried ______ meters down to put this dangerous material far from people. Do not dig or drill ______ meters down. Do not drill and use a well for water without checking for radioactivity. Do not do anything to change the rocks or water in this area. Disturbing the site may cause exposure of humans to radioactivity. This may result in sickness and death. Illness may not occur until several years after exposure. This disposal site was built by the United States Government in ____.¹²³

¹²² Ibid. ¹²³ Ibid, 266. In terms of the tone of the message communicated, Kaplan proposed that the team should stick to these types of purely informative messages rather than threatening ones. An example of such a threat can be seen on a Phoenician inscription and is "representative of many ancient linguistic imperatives": Whoever you are, ruler and (ordinary) man, (do) not open this resting place and (do) not search in it for anything, for nothing whatsoever has been placed in it.¹²⁴

These types of messages generally promote curiosity more than restraint. Givens notes, "while the messages might have stopped some would-be robbers, they also announced, implicitly, by their very presence and absurd, self-contradictory denials, that 'something valuable *is* here.' Furthermore, "nothing that says 'Touch this rock and die'" is likely to work, since it hasn't in the past.¹²⁵ Eventually someone in the course of history will 'touch a rock' and live, undermining the warning and actually increasing the probability of repeated intrusion. Scary faces were also deemed ineffective, as they function in much the same way. The Markers Teams concluded that these scare tactics must not work or else "…museums and private collections wouldn't abound with such guardian figures removed from burial sites."¹²⁶ However, faces showing sickness and horror may be used as an addition to the warning system since they would accurately describe the human reaction to the interred threat. In summation, only components that provide " a credible conveyance of the dangers of disturbing the repository" should be used. All scare tactics and threats should therefore be avoided.¹²⁷

In addition to the surface markers discussed above, Kaplan suggests that subsurface markers be placed as safeguards in the event that the surface markers are removed or otherwise damaged. For these markers, the dull homogenous granite will be swapped for brightly colored pottery work. Because pottery has an 8,000-year history and can be permanently glazed in striking colors, it is the perfect material to attract the attention of those digging at the site. The iconography and text could be impressed into the clay of the marker, so that even if the glaze fails, the messages will endure.

¹²⁴ Givens, 174.

¹²⁵ James M. Pethokoukis, "A Curse to Last 10,000 Years: A Nuclear Waste Dump needs a 'Keep Out' Sign with a long Half-Life," US News and World Report, 133, no. 5 (2002), 51.

 ¹²⁶ Sandia National Laboratories, Expert Judgment on Markers to Deter Inadvertent Human Intrusion into the Waste Isolation Pilot Plant, (Washington D.C.: Division of High-Level Waste Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, 1992), 4.
 ¹²⁷ Ibid

All of these marker schemes are based on the "idea that civilizations may rise and fall, but curiosity, reason, and fear of the unknown will persist."¹²⁸ However this is an assumption that is dangerous to make. The test of time reveals that the former more often than not ends up prevailing over the latter two enduring qualities of mankind. Living in an age of high technological and scientific sophistication, our collective attitude toward the unknown has shifted. As the "unknown's" of the past are slowly liberated from the veil of mystery through new discoveries and research, the concept of the "unknown" may seem more like an opportunity for discovery than a threat. It is therefore naïve to assume that our descendents will regain the fear that their ancestors labored to lose. When confronted with the discovery of King Tut's burial room, scientists did not flee at the threat of an unknown curse. Thus, while hiding things in the ground with an accompanying warning may "provide at least the illusion of cheap access to deep time (and offer employment to generations of archeologists as yet unborn," it will not necessarily inspire fear.¹²⁹

Kaplan does not discuss this specific issue in depth. Nor does she Address the mechanics of message creation and reception that would later be tackled by semioticians working on the WIPP project. What she does provide is valuable information on materials — what lasts, what doesn't, and how it should be arranged for maximum durability and impact. In terms of material integrity, we generally do not know what didn't work, since these objects perished long ago. A few other authors provide Additional materials conservation suggestions to complement Kaplan's research.

Benford: Astrophysicist and Science-Fiction Author

Benford discusses materials possibilities in terms of what may be desirable to future generations. Noting that "most vandals do not like hard work," Benford echoes Kaplan's suggestion that the markers be forged from a heavy, immovable material.¹³⁰ Benford also cites many successful archeological examples that testify to stone's longevity in a variety of climates — from Nabta, a 6,000 year old stone in the Sahara to the Newgrange passive grave, built in 3,150 BC by Stone Age farmers in Ireland.¹³¹ He notes that the latter's clever design — strategically placed grooves carry rainwater off and away from the monument — prevented water and salt damage. Benford also speculates that

¹²⁸ "Deep Time: Across the Abyss," *The Economist*, 349, no. 8099 (1999), 27.

¹²⁹ Ibid.

¹³⁰ Benford, 57.

¹³¹ Ibid, 58.

although it is wise to build with materials possessing no intrinsic value today, it is ultimately impossible to determine what materials will be desirable to future generations. Since we are slowly exhausting tour natural resources, almost any material could become valuable in 10,000 years.

Benford's discussion of ancient monuments addresses their geometry. He explores the types of messages sent by physical form such as shape and proportion. He argues that human beings do indeed perceive geometrical messages, although their effect is registered subconsciously.¹³² These "geometry clues" appeal to our senses in a different way than languages or pictures. Architects, for example become acutely aware of the way in which spatial ratios effect the viewer. The architects of the Parthenon designed the pediment so that its dimensions could fit almost exactly into a Golden Rectangle. (Figure 15) Perhaps these ancient ratios hold the key to perfect proportional stability and power — feelings exuded by the elegant geometry of monuments such as the Parthenon or the pyramids of Giza. Furthermore, revealing that we, the message senders understand and obey mathematical logic, may help the messages to gain credibility in the eyes of the message receivers. If the site merely warns about danger without demonstrating the reliability of the message sender, the warning may not be taken seriously. Furthermore, Benford notes that the sheer mass of the pyramids inspires awe and attracts attention — bulk speaks. In terms of form, an editorial writer from the Economist suggests using irregularly shaped materials. Although this suggestion may conflict with Benford's concept of rational gestalt, it will prevent these materials from being pillaged and reused for future building pursuits.¹³ It is, after all, much easier to reuse a cubic brick of stone rather than an amorphous chunk of granite.

However, the Economist article also provides evidence from the ancient world that clearly inscribed messages often befuddle archeologists today.¹³⁴ The Phaestos Disc, dating from 170 BC, cannot be translated, in spite of decades of effort. (Figure 16) Discovered in Crete, it contains a total of 241 symbols from an unknown 45-symbol alphabet. Because no other examples of this alphabet have been found and because the purpose of the disc itself is unknown its meaning cannot be

¹³² The length of [Stonehenge's] two oval axes are in the ratio 5:3, this is close to the Golden Section, 1.6280..., a number of great import to the ancient Greeks, and which we shall meet again. Such deep aesthetics cross cultures. It is also worth noting that the perimeter of the Great Pyramid, divided by its height is 2π , so that the height was set to equal the radius. The symbol of the sun god Ra was a circle, so when Ra rose in the morning the pyramid greeted him with a geometric analog of himself, a hailing from his subjects (Benford, 21). ¹³³ Benford, 3.

¹³⁴ Economist, 2

interpreted. However, much older characters can be read quite clearly due to their representational quality and the simplicity of their messages.

Archaic tally notions and primitive notched calendars are some of the first written messages. The simple numerical tally mark serves as the first step to written language, as the mark — an abstract symbol with no inherent meaning — is being used as a stand-in to "count" objects in the natural world.¹³⁵ These tally notions are the first abstract expressions of a physical reality. These types of marks are abundantly found in objects from the ancient world and are also easily identified and read by modern archaeologists. However, the capability of this type of communication ends at counting — these universally used marks cannot carry sophisticated and detailed messages. Other message systems also fail due to their inability to carry detailed messages. Many monuments serve to simply 'announce' the presence of a people rather than transferring a specific, detailed message. The message, if there is any to be found, seems to only specify that a particular culture "was here."¹⁰⁶

In summation, the archeological objects and monuments studied by Kaplan and others provide a good foundation in designing a system to prevent human intrusion into the WIPP repository, but aren't comprehensive. Valuable insight has been provided in terms of material durability. However, while many ancient monuments succeed in communicating a sense of awe and sophistication, their 'keep out' messages have ultimately failed. Thus, how can a permanent universal 'keep out' message be formed? In order to answer this question, many members of the design teams turned to the field of semiotics for influence. Since semiotics is essentially "the science of signs," several strong influences from this field of study were referenced in the Markers Teams reports.¹³⁷ However, it is possibly more accurate to define semiotics as a type of study rather than a field of study due to its interdisciplinary nature. Anderson quotes Pierce to demonstrate:

This universe is perfused with signs. This quote anticipates the leaky boundary between semiotic scholarship and the traditionally specialized research parallel to it

¹³⁵ Schmandt-Besserat, 1.

¹³⁶ Benford, 67.

¹³⁷ Givens, 160.

in the humanities, social sciences, life sciences, and conceptual sciences...Above all, semiotics must be a perspective.138

Since semiotics studies "both verbal and averbal systems of communication," it can assist in judging the effectiveness of these systems of communication.¹³⁹ Although research conducted from a semiotics perspective often abstracts from the object, the semiotics research conducted on behalf of the WIPP project is, in general, strongly rooted in studies of archeological objects — often referencing the same objects studied by Kaplan from a different perspective.

Givens: Anthropology and Semiotics

David Givens, of the American Anthropological Society and member of Marker Team B investigated how ancient objects communicate. Like Kaplan, he studies objects whose lessons can be instructive in the design of a deep time message system. His report considers "problems of long-term future communication — i.e. of moving detailed present-day information across several millennia from the viewpoint of semiotics, information theory, anthropology and cross-cultural psychology."140 He offers a semioticians's history of the sign, as transmitted through ancient artifacts.

Givens begins with the "oldest human sign artifacts."141 These artifacts include engraved animal bones, such as the Bordes Ox-Rib (300,000 BC) and the Blanchard bone (30,000 BC). Both contain distinctly patterned markings that express the general message: 'made by man.' Similar to Benford's point concerning many ancient objects' tendency to "announce" rather than "tell," many of these artifacts simply express that "man was here" — such as the "Cro Magnum handprints found in Gorges Cave, France or the macaroni finger marks in the cave ceiling at Rouffignac Cave."¹⁴² About 40,000 years ago "the archeological record evidences what can be termed a semiotic explosion, a proliferation in human sign-making activities."¹⁴³ Realistically carved animal and human forms began emerging 20-30 thousand years ago, as evidenced by examples such as the Venus of Laussel and the numerous carved forms in Vogelherd Cave. These signs "communicate not only 'made by man' and 'man was

¹³⁸ Myrdene Anderson et al., "A Semiotic Perspective on the Sciences: Steps toward a new Paradigm," Semiotica, 52-1/2 (1984), 8.

Sebeok, 1. ¹⁴⁰ Givens,159.

¹⁴¹ Ibid,161.

¹⁴² Ibid.

¹⁴³ Ibid.

here' but also more complicated messages: 'horse,' 'lion,' 'leopard,' 'bison' ..."¹⁴⁴ Cave art also began appearing as long ago as 30,000 BC. The symbolic characters pictured, such as "geometric and tectiform figures" cannot be deciphered, but the more naturalistic images — the horses, bison, and deer — can be immediately read by the modern viewer.

Some modern scholars have speculated that these signs possess syntactic or "sign-to-sign" meaning. The painting of human handprints on the edges of paintings of horses in France's Pech Merle Cave, for instance, contributes to the hypothesis that the ancient artists meant to convey man's ritualistic power over the animals. (Figure 17)

Givens notes that 11,500 BC was a major turning point in the development of pictorial signs, as narratives began to emerge. "Storytelling" and "dramatization" began to show "the consequences of actions" as well as gender signals and social behavior.¹⁴⁵ The development of "flat-surfaced sign vehicles (walls, ceilings, animal skin, sides of containers, clay tablets, etc.)" increased artistic production, as did the "arrival of urbanization and the full-time artist and scribe (ca. 6,000 BC)."¹⁴⁶ Syntactic meanings relied heavily on juxtapositions in prehistoric (pre-writing) times.¹⁴⁷ For example, the Bird-man of Lascaux, illustrates the relationship between a bison, a rhinoceros, a bird-headed man, and a barbed pike on a cave wall.¹⁴⁸ (Figure 18) There is a natural disposition to see relationships between adjacent signs.

An example of narrative form comes from Akrotiri — in the form of a long Minoan fresco (3,500 BP) which depicts the consecutive sequence of events in a naval battle. (Figure 19) However, although sequential art has been used throughout history as the standard visual means for depicting narrative, it is also inherently confusing. It is difficult to determine whether figures are multiples or merely the same figure at different points in time. The paintings of the Italian Futurists, notably Balla's *Dynamism of a Dog on a Leash*, display the complexity of multiples in pictorial space. The multiple appearances of the dog's tail may be correctly read as the multiple positions it assumes while being vigorously

¹⁴⁴ Ibid.

¹⁴⁵ Ibid, 162.

¹⁴⁶ Ibid.

¹⁴⁷ Ibid, 164.

¹⁴⁸ Just as we see significances in relationships by virtue of sign arrangements (Givens provides the example of "A touches B, A is between B and C, etc."), ancient encoders showed relationships between signs by their placement.

wagged, or misread as representing multiple tails. Many 20th century artists play off of the ambiguity of this pictorial convention.

The use of pictographs also radically changed the notion of the sign — markings began to more closely resemble written language. Pictograms became more simplified and standardized, possessing a logographic or "word-concept" meaning. "One of the earliest examples of pictographic writing (5,300 BP) is a small tablet from the Mesopotamian city of Kish, which includes among its symbols simple inscriptions of a foot, a hand, and two human heads."149

The conventions employed in the development of these pictographs seem to "have very deep roots in human perception and cognition."¹⁵⁰ The drawn line itself seems to be a cultural universal underlying Near Eastern Cuneiform writing, Egyptian Hieroglyphics, and Chinese writing systems, as well as being the integral component of most non-linguistic picture writings. These representational signs are often found framed with a line which Givens interprets as "the gestalt, cognitive property of the enclosing frame itself in tandem with the brain's perceptual sensitivity to edges."¹⁵¹ The pictographic symbols eventually led to written scripts, which drained many pictographic systems of their original naturalistic quality. And while decoding ancient written languages has yielded rewarding, detailed information, it is sometimes "at the expense of years of sometimes painful decipherments." 152

Givens also discusses ancient monuments as a type of semiotics group. Not surprisingly, he notes that "their most telling sign qualities are 1) durability and 2) large size — they command an onlooker's attention."¹⁵³ He speaks briefly about the geometric metaphor, noting that only human beings seem naturally inclined to build in shapes such as perfect triangles, rectangles and squares.

From this brief history of the sign, Givens concludes that the past provides us with seven main lessons that can be used to communicate with the distant future.

Semiotic Lessons From Antiquity

1. Use iconic signs. They can be decoded faster and easier than symbols. Iconic clarity can be promoted using principles of "Isotype." (Figure 20) Rather complex culture-free meanings can be conveyed in an iconic medium.

45

¹⁴⁹ Givens, 162.

¹⁵⁰ Ibid, 163.

¹⁵¹ Ibid. ¹⁵² Ibid.

¹⁵³ Ibid.

2. Use pictographs. Simplified line drawings have had a worldwide prehistoric distribution. The "stick" figure man, the human face, the opened hand, animals and birds, and numerous other pictograms have been used as information carriers by many cultures for millennia.

3. Employ narrative principles. Iconic scenes and pictograms can be sequenced to tell stories. The syntactic ordering, especially the direction of reading, should be marked clearly.

4. Include alphabetical (phonetic) scripts and several of the world's most commonly used languages. Ideographic, syllabic, and mixed ideographic-phonetic scripts, and unknown languages, have been most difficult for contemporary scholars to decipher.

5. Include large monuments — designed to manifest complex internal and external structure — for visibility and permanence. "Made by man" should be obvious from a distance.

6. Employ redundancy by using a strategic mix of signs and sign vehicles. Abundant physical evidence will aid interpretation and function as a hedge against decay, vandalism, and natural processes of disruption.

7. Warning (i.e. "ought") messages will be ineffective without accurate, supporting factual (i.e., "is") messages.¹⁵⁴

Based on these lessons learned from antiquity, as well as his levels/redundancy concept, Givens

devises a numbered list of criteria for developing the warning system. This list is broken up into

"signs" and "sign vehicles" (or what has previously been referred to as "small-scale messages" and

"large-scale messages," respectively).

Signs

- 1. *A mixture of iconic, symbolic, and linguistic signs should be used.* The variety of message types will make the communication easier to decode in the future.
- 2. Iconic signs should be used in conjunction with written scripts to convey levels of cautionary,

basic, and technical information. "One picture is worth a thousand words," which Givens notes comprises both images' primary strength and weakness. Iconic messages are difficult to control in spite of modern graphic design's precision. The combined use of iconic and symbolic signs with linguistic messages would help strengthen the communication. Givens also notes that the useful innovation of "minimax" — or the principal of simplifying iconography without the loss of meaning — should be used so that the "smallest number of graphical units are needed to convey the greatest amount of information."¹⁵⁵ Givens uses the example of Neurath's Isotypes as using this strategy. The Isotype, intended to communicate universally to modern humans rather

than the distant future conveys tangible human concepts in the most direct manner. However, it should be noted that Neurath's Isotypes often fall short of this intention — many are completely inscrutable.

- 3. Iconic narratives should play a central role in communicating level II and level III information. Furthermore, in regards to these more complex messages, the proposed pictographic sequences should be shown to a "test audience" comprised of individuals from varying cultures to determine their effectiveness.
- An international graphic symbol or emblem for biohazards should be put into general use. Of course, this symbol already exists, it is just not widely known. Perhaps implementing a supporting education program would help.
- 5. Written languages should be used to encode the detailed, level IV information.
- 6. *Principles underlying sequential orderings of signs should be clearly marked.* He suggests that this be arranged linearly, to be read top-to-bottom and left-to-right.
- 7. *Information should be organized into four levels of meaning.* These levels are of increasing sophistication and detail.
- Signs their shapes, syntax, and meanings should have a pancultural significance. This should be done by "gearing" the messages to the human Umwelt and worldview.

Sign Vehicles

- 9. *A mixture of hyper durable sign vehicles should be used.*
- 10. The warning effort should include a large number of sign vehicles in order to benefit from properties of message redundancy.
- 11. The layout and grouping of sign vehicles at a site should portray a highly ordered, structured, esthetically-pleasing whole, "greater than the sum of its parts." The components should be based on geometric principals and patterning, a hallmark of man-made monuments.
- 12. Many large, permanent standing monolithic stones should be used.
- 13. *A monumental earthwork in a symbolic shape should be used.*

- 14. The earthwork and monoliths should claim the site surface boldly, cover a large area, and be visible from a great distance. As Foote also remarks, the presence of a monument would stimulate a surrounding oral tradition. The monument would be the "physical tether" for such a tradition.
- 15. The earthwork and areas around the largest monoliths should be salted with thousands of information-rich "tablet" vehicles.

According to Givens, the use of these devices ensures that vandalism will be reduced, and that information will be continually broadcasted in a "time-release manner."

Foote: Semiotics

Further influence from a semiotics perspective comes from attempts to communicate with extraterrestrials via messages inscribed on deep space flights. Although these sources were not explicitly referenced in any of the members of the Markers Teams' reports, the teams would have presumably been aware of the projects, since they or their colleagues have contributed to such projects. The description of a design team member as "an astronomer who searches for extraterrestrial intelligence" strengthens this likelihood.¹⁵⁶ Semiotician Kenneth Foote writes extensively on these projects within a report investigating the "material foundation of human semiosis." Foote begins his discussion by setting up the semiotics context of the project, which closely resembles the challenge of the WIPP.

[The meaning of objects] depend upon the sharing of knowledge and experience among people who use them...The objects of daily life aid memory because people share the common information which defines their significance, and often little effort is required to call this context to mind. There are many situations, however, where commonalities of experience are lacking, or are lost altogether, and an object's meaning is lost.¹⁵⁷

One such communication problem is the "messages which have been attached to spacecraft destined for intergalactic flight."¹⁵⁸ Plaques have been affixed to the sides of the Pioneer 10 and 11 spacecraft (1971 and 1972) and each Voyager spacecraft (1977), the latter also containing a gold phonograph

¹⁵⁶ Sandia National Laboratories, 1.

¹⁵⁷ Foote, 249.

record and record-player for listening to recorded greetings and samples of popular music. Since "few assumptions could be made about the type of civilization and living beings which might eventually discover them... all messages had to be marked into units which could be assumed to be familiar to other civilizations."¹⁵⁹ (Figure 21) The graphical messages sought to establish a sense of constants this way, assuming that the "beings recovering the message would be rational, intelligent and understand the universe in scientific terms." Correspondingly, illustrations included the hydrogen atom, the process of electromagnetic radiation, and relative relationships of celestial bodies in the galaxy.¹⁶⁰ Perhaps the most interesting "message" included on the plaque is the picture of the two welcoming human beings, standing in front of what is presumably the Pioneer spacecraft.¹⁶¹ The drawing stresses human beings' opposable thumbs, as well as the distinctions between the sexes. Interestingly, the woman stands in a controposto pose and both figures lack modeling. The adjacent tick marks convey cryptic mathematical relationships, which Tufte explains is the ...

Binary equivalent of decimal 8, between tick marks indicating human heights. The hydrogen wavelength (21.11 cm) multiplied by 8 yields the woman's height (169 cm or 66 in).162

Of course, the average human viewer would probably not grasp this significance unless prompted to closely examine the mathematical relationships between the elements. Foote acknowledges this stating, "these messages are quite difficult for humans to decipher because most day-to-day communication can assume a range of common experience far removed from the spectra of the hydrogen atom."¹⁶³ But even if extraterrestrials did exist, did receive the message, and could decode it, would any significant meaning be shared? Foote says no. Since the information conveyed "would pertain almost exclusively to our scientific knowledge...the plaques contain little more than basic information."164

lbid.

¹⁶³ Foote, 251.

164 Ibid.

¹⁵⁸ Ibid.

¹⁵⁹ Ibid.

¹⁶⁰ Ibid, 250.

¹⁶¹ Edward Tufte, Visual Explanations: Images and Quantities, Evidence and Narrative, (Cheshire, Connecticut: Graphics Press, 1997), 150.

However, this should not discourage from the task of implementing long-tern nuclear waste warnings, which Foote considers an imperative task for semiotics. He advocates an approach that interweaves "artifact and action" wherein the materials expression (the marker) is supplemented by cultural and oral traditions.¹⁶⁶ Foote suggests that the landscape, as a concept, will be a constant between us and future human beings. Landscape forms the human basis of communication and should be employed heavily in the design of a warning system. Indeed, many scholars "attempt to frame the relation of people to landscape in terms of communication."¹⁶⁶ He asserts that our ecological environment affects the way in which we communicate. It forms systems of communications in a manner similar to built environments. However building "durable long-lasting physical markers" is not sufficient in ensuring the longevity of the message.¹⁶⁷ Foote recommends the use of maps, an international biohazard symbol, written documents, durable markers, and a "relay system" to create a "synergistic relationship" to preserve meaning¹⁶⁸.

Sebeok and Tannenbaum: Semiotics and Communication

The concept of a relay system was also discussed in two reports drafted for the HITF by Sebeok and Tannenbaum. The concept behind the system is simple — if the warning message isn't renewed from time to time, its communication strategies, language, and substrates risk becoming obsolete. Therefore, if we can persuade future generations to continually "renew" the messages by re-translating the relevant documents and text, and by transferring messages on obsolete substrates to newer media (for example, from microform to DVD), the message will last. Although the question remains of how to monitor the integrity of the information passed along in this process — much like the game of "telephone," information may be altered in translation. Also there is no safeguard to ensure that future generations will actually do their job. Sebeok suggests that in order to motivate "future generations to obey the injunctions of the past," legal and moral imperative should be set in place.¹⁰⁰ If these, too, seem unlikely to work, perhaps implementing a "veiled threat" stating that to ignore the mandate would be tantamount to inviting some sort of "supernatural retribution" would work. Sebeok proposes 250-year intervals between message renewal. However, memory, even institutional memory, is too

¹⁶⁵ Ibid, 253.

 ¹⁶⁶ Ibid, 246.
 ¹⁶⁷ Ibid, 256.
 ¹⁶⁸ Ibid, 257.

short for this extended time frame. Perhaps if legal imperatives are put in place requiring that the messages be translated every decade or so, they will provoke a continuing cultural conversation as well as functioning as a safeguard against "delinquent generations." Even if a series of ten consecutive generations pass without renewing the message — due to world war or another significant disruption — the information will still be legible 100 years later.

Sebeok's other major contribution to the body of knowledge on the topic of deep time communication is his distinction between "natural" and "conventional" messages, which helps to clarify many of the concepts vaguely broahed in Tannenbaum's and Goodenough's reports.

Conventional messages are those whose power to signify is thought to depend on some prior agreement, presumed to have been reached at some temporal juncture, and thereafter accepted as a matter of custom — such as, most importantly, messages cast in spoken or written utterances...The meaning of a conventional message — whether verbal or not — is invariably circumscribed to a time and place.¹⁷⁰

Conventional messages will therefore be useless in the pursuit of creating a "timeless" message. Natural messages should instead be used, as Sebeok defines them. "Natural messages…have the power to signify the same things at all times and in all places, precisely because their interpretation does not presuppose a familiarity with the conventions of a particular group."¹⁷¹ For example, large dark clouds are an indication of rain in the near future at any time and in any place. These types of messages are therefore " particularly pertinent to the present responsibility of the Human Interference Task Force."¹⁷² Ultimately, through the use of these verbal messages, as well as varied levels of communication strategies, the "seemingly insurmountable power of time" can be conquered.¹⁷³ According to Sebeok, communication is not merely our only option in this pursuit, but the key — since the "social function of communication is the ensuring of continuity in society."¹⁷⁴ "This is the timebinding function of social communication."¹⁷⁵

Influence was also taken from various design fields. Naturally, theories of communication and information design were researched, as well as the field of environmental graphic design. This

¹⁶⁹ Sebeok, 4.

¹⁷⁰ Ibid.

¹⁷¹ Ibid.

¹⁷² Ibid.

¹⁷³ Ibid, 2.

particular body of knowledge was brought to the project by design team leader, Michael Brill, an environmental graphic designer from BOSTI Workplace Environments and professor at the State University of New York in Buffalo. Whereas the influence of semiotics provided insight into how denotative messages might be constructed, information imparted from the design fields was used to create connotative message through form and placement. Tannenbaum distinguishes between the two message types as they relate to the WIPP project:

Denotative Elements. The main content to be communicated is essentially factual in nature. The required basic information is relatively straightforward and unambiguous: (a) the existence of the repository, (b) its location, (c) its contents, and (d) the risks of intrusion...Connotative Elements. Since the human species does not live by factual information alone, its messages often contain connotative meanings, various emotional feeling — tones and nuances of impression that may be more significant in terms of intention and effect than the denotative content.¹⁷⁶

The creation of the connotative elements of the site was plagued with the same sort of uncertainties about the future message recipient as the denotative message-making process. However because connotative messages provoke and rely on emotion, the viewer's response is largely subjective and therefore difficult to control. However, according to Tannenbaum, areas of greater and lesser ambiguity exist. Tannenbaum breaks the less-ambiguous areas into two main categories — messages of attraction and repulsion — either of which may be employed in preventing intrusion into the WIPP repository. Things displaying appealing connotative messages could be built above the site, including camping grounds, parks, or even a "nuclear energy museum."¹⁷⁷ This approach is based on the idea that people of the future will be less inclined to despoil a place that is attractive and useful to them. The opposite strategy may also be effective according to Tannenbaum. By utilizing a repulsive connotative approach, the site would be inhospitable and unwelcoming, discouraging people from spending time there. However, Tannenbaum doesn't offer any familiar "types" of places that would fulfill this function. Michael Brill would suggest that this is not a coincidence. He notes, "Human kind has very

¹⁷⁴ Ibid.

¹⁷⁵ Ibid.

¹⁷⁶ Sebeok, 12.

¹⁷⁷ Tannenbaum, 12.

little experience with negative monuments."¹⁷⁸ However, Brill believes that this is exactly what we must build — a negative monument that forbids entry. One author, commenting on Brill's unusual design theory, dubbed the pursuit an "oxymoronic application of his expertise."¹⁷⁹ Indeed, the development of keep-out signs has not progressed much further than the verbal statement "Keep-Out." Another common strategy entails threatening the potential intruder with physical harm by use of barbed wire fences or electrical "invisible fences." This would have limited effectiveness in the 10,000 year span of the WIPP project, since a truly dangerous site would probably be torn down by future generations.

Brill: Environmental Graphic Design and Form Archetypes

Brill's field of expertise, environmental graphic design, revolves around optimum spatial arrangement of elements — in the workplace this would concern issues of flow and privacy. This practice strongly ties into the human experience of space, seeking spatial solutions that fully accommodate the physical needs of human beings, and directing people easily through spaces. Design frequently attempts to control the actions of people moving through spaces: billboards beckon motorists from the road, and are strategically placed for maximum impact. (Figure 22) These advertisements play on the connotative aspects of space. The denotative messages are placed for maximum impact — they can be viewed from a distance and find their voice through strategic placement.

Similarly, Brill's design theories reflect a belief in the ability of space to affect human emotions. However, it is uncertain whether Brill thinks that such messages are capable of transcending the simple directing of actions through repulsive and attractive elements. Tannenbaum notes that the site has a more complex message to communicate. In terms of connotative — and to a lesser extent, denotative messages — the main communication design problem resides in expressing the site's ambivalence. Since "... the site is both safe and dangerous — [it] creates a special communication problem, particularly if a rather parsimonious communication code is employed near and at the site."¹⁸⁰ The message needs to express that the site is safe above the surface, but incredibly dangerous below the

¹⁷⁸ Zoe Ingalls, "Monuments that Warn: 'Beware. This is Poisoned, Destroyed, and Dead Land'," Chronicle of Higher Education, 39, no. 17 (1992), B4.

lbid.

¹⁸⁰ Tannenbaum, 13.

surface. Should the risk be overstated — setting forth an extreme warning against the site as a whole — or understated — allowing the people to use the surface area without the feeling of extreme danger? She outlines the risks of both. If the message is understated, the message might not read as a warning at all, leading to intrusion at the site but if the message is overstated, the message might have the same effect as the "Touch this rock and die" strategy. According to Tannenbaum, the key lies in moderation and accuracy — warning against the extreme dangers of the subsurface, while showing the surface area is safe. Alas, the spatial arrangement of the site is inherently confusing. Since almost all mapping is done at a horizontal level., it becomes difficult to differentiate where the "safe" space lies in relation to the danger when a space is arranged on a horizontal axis. Indeed, human beings have always occupied and developed space on a horizontal level, with the exception of the relatively recent innovations of skyscrapers. Thus, differentiating between spaces that lie in a vertical orientation to one another proves for a challenging design problem, often yielding complex solutions.^m

Ultimately, Tannenbaum recommends utilizing a moderate connotative approach — one that emphasizes simply, "proceed with caution" — relegating the burden of communicating specific warnings to the denotative messages. Brill is also reluctant to express such ambiguities through a connotative message, because its strength comes by virtue of its simplicity and single-sided nature. Subtlety weakens this type of message. Unlike Tannenbaum, he suggests overstating the message through strong, clear, signage. Brill states that the "natural power of place" can be "very powerful for people… in communicating at a visceral level."⁴⁸² Brill looked to what he dubs "physical archetypes" for inspiration in designing a truly repellent place. These archetypes transcend language and cultural bounds — compiled as a result of "ten years of studying monuments, memorials, and other places, both exalted and humble."¹⁰⁵ These archetypes are "non-linguistic, species-wide, coming before culture, and working independently of it."¹¹⁴

When they are "charged with meanings felt/sensed," places are defined as archetypal. Brill's list of examples includes Stonehenge, the pyramids, and the more recent Vietnam Memorial. These places

¹⁸¹ To see Edward Tufte's solution to such a design problem, see his 3-D map of the National Gallery in Washington. (Figure 23)

¹⁸² Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years, (Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. [BOSTI], 1991), 4.

¹⁸³ Ingalls, B4.

are defined as archetypes since they communicate "species-wide inherited templates in the mind of form and meaning." Although Brill does not expand upon the specific formal/visual aspects that create the meaning within these spaces, he relates them to archetypes in mythology. Benford also connects Brill's archetypes to myth by comparing them to the work of Joseph Campbell and his "species-wide myth themes: virgin birth, great mother...the land of the dead, the great quest journey..."¹⁸⁵ "We extract these stories from our environment because we are hard-wired to 'see' them popping out."¹⁸⁶ They are "patterns that order chaos."¹⁸⁷ The patterns emerge as a result of an emotional anthro-centric response to the environment.

Although Brill fails to give concrete design guidelines that reveal which physical and visual properties derive from archetypal spaces, he provides an extensive analytical example outlined in bullet points.

An Example of Meaning-in-Form:

- Vertical Stone Marker...Obelisk...Stele...
- Standing Stone...Memorial Column...Spire...
- Characteristics: vertical; solitary; apparent; symmetrical; durable; white; public; in privileged location
- Use: From our beginnings, and still, to commemorate, now and "forever", deeds/events we idealize.
- Meanings: (multiple and bundled)
 - Embodies aspiration, reaching...connects us to the ideal, the up there
 - Directs us to virtue, light, the gods, the good
 - "Standing up" with pride
 - Something important to honor is here
 - Sacrifice of a group's resources, space and effort to honor a memory or ideal
 - Exhorts descendents to honor the memory¹⁸⁸

These are qualities that we sense — rather than read — from many of the longest-lasting man-made

monuments.

Another important point raised by Brill is that humans, in an enduring anthro-centric view of the

landscape, are inclined to look at places as potential dwellings. Places are either hospitable or

inhospitable to human activity. Form-archetypes should therefore be used that will communicate "

¹⁸⁵ Benford, 65.

¹⁸⁶ Ibid.

¹⁸⁷ Ibid.

¹⁸⁸ Brill, 4.

Beware. This is poisoned, destroyed, and dead land."¹⁸⁹ "The place should not suggest shelter, protection, or nurture. It should suggest that it is not a place for dwelling, nor for farming or husbandry."¹⁹⁰ A form-archetype that would convey such a message should contain "sharp points, darkness and dislocation."¹⁹¹ "This isn't intellectual stuff," Brill notes, "the body almost intuitively understands it."¹⁹² Biologist John Appleton intellectualizes the concept a bit, stating that these cues can be traced back to our primordial subconscious and the way in which early man related to the landscape. Survival was the reward for those who were attuned to "... Hazard-rich images or smells [which] reach right into the brain, arousing anxiety that can only be resolved by taking action, the fight-or-flight response."¹⁹³ However, designing these elements, with the self-conscious purpose of generating this specific response presents the same problems as encountered in developing an artificial ritual-andlegend tradition. These things occur organically, their meaning surviving perhaps only because of their organic nature. The success of contriving such a phenomenon is unprecedented. However, Brill notes that we can use hazardous forms provided by the natural world to send a message of warning.¹⁹⁴ According to Brill, these forms are already deeply ingrained in our subconscious. Forms such as thorns and spikes, inspired by forms threatening to the human body from the plant world, should be heavily employed in the design. Non-geometric elements and an erratic scattering of elements will conflict with the human attraction to symmetry and order in space, creating an emotional discordance.¹⁹⁵ Human skulls also have historically held a powerful distressing effect. Benford notes that the fear generated by the image of a skull is very deeply rooted in human consciousness, stemming from

...our origins, when the sight of skulls warned that predators that preyed on primates were about...Predators on early primates would tend to leave the heads in their wake (difficult to eat), and automatic fear of these leftovers would prod other primates to quick evasion.¹⁹⁶

- ¹⁸⁹ Ingalls, B4.
- ¹⁹⁰ Sandia National Laboratories, 6.
- ¹⁹¹ Ingalls, B4.
- ¹⁹² Ibid.
- ¹⁹³ Benford, 65.
 ¹⁹⁴ Ingalls, B4.
- ¹⁹⁵ Brill, 6.
- ¹⁹⁶ Benford, 78.

56

However, our cultural associations may have overcome our primordial instinct in regards to skull imagery. Benford cites an experiment with three-year-olds that were shown skull imagery and excitedly exclaimed "Pirates!" rather than displaying any aversion to the image.¹⁹⁷ Skull imagery was thus omitted from being considered "universal" by the design tem. However, the same sort of displacement of meaning could probably occur with any symbol, given a vast expanse of time.

In his individual report, Brill summarizes his suggestions for archetypal imagery which he recommends using in the WIPP marker design:

Archetypal Imagery Used for Site:

- not an honored place...what is here is odious
- dangerous emanations from this area
- bristling, wounding spikes and thorns
- here, disorder (Chaos) is replacing order (cosmos)
- poisoned, destroyed, parched land
- uninhabitable, unproductive land
- no "here" here...the void...a black hole¹⁹⁸

All of these points are directly tied into human beings' connotative response to elements in the landscape.

Distal Markers

Tannenbaum includes suggestions for additional distal markers. Distal markers, "although not absolutely essential" admits Tannenbaum, would provide advanced warning — alerting individuals to the fact that they are approaching "some special place."¹⁰⁹ Noting that in several countries, including the United Kingdom and Germany, requests have been made "for appropriate markers indicating nuclear plant and waste disposal sites to appear on road maps and highway signs," Tannenbaum suggests that the American public will also desire such markers.²⁰⁰ The placement of a sign in space, detached from the location that it is signifying, must reflect an awareness of the way that the message recipient will approach the site. The marker must be formed with consideration to such factors as the direction and speed of the viewer's movement. The placement of the sign must take into account the

While all of Brill's suggested form archetypes were intended to be used at the site's location,

¹⁹⁸ Brill, 8.

¹⁹⁹ Tannenbaum, 3.

presumed route taken by the message-recipient. This concept is discussed at length in the first chapter of Denise Scott-Brown and Robert Venturi's Learning from Las Vegas, which addresses the relationship between the viewer, the road (the highway in this case), the sign (an advertisement), and the signified place (a casino).²⁰¹ The distance between the point where a casino's flashing billboard comes into sight and where the physical building stands must be perfectly calibrated to accommodates the viewer's response time when traveling at X mph. The arrangement of the entire Las Vegas strip functions this way — the signs and places alternate in a calibrated rhythm. Assumptions about the viewer's speed while traveling, viewer reaction time, and route have dictated the placement and size of the signs in the case of road travel. These factors would also have to be considered in the development of distal markers for the site. This poses a problem, since these factors are unknown. In the case of the WIPP repository, distal markers could be placed along the limited access roads leading to the site. However, as Tannenbaum notes, these forewarning markers will remain effective only as long as the current roads are used as the primary route for entering the site. He optimistically suggests that the signs may be maintained by future generations, who will alter their placement according to their needs. Legibility and Graphic Design

Aside from influencing the construction of connotative messages — through the emotional properties of form and through spatial placement decisions — the field of design also provided the teams with insight into issues of legibility. Tannenbaum writes that care must be taken to ensure the legibility of the markers since "Visual signs have to be seen to be perceived and processed."²⁰² Legibility is the transaction that occurs between the "...object or symbol and the perceiver."²⁰³ Although a level of subjectivity always resides in this transaction — what is perceived as legible varies from individual to individual — there exists accepted standards that aid in legibility. Factors such as "color relationships, lighting, spacing, viewing angle, etc." affect the legibility of symbols or objects.204 Like the communication of distal messages, the size of the sign and distance from the viewer will also affect the legibility of the message. When, like an approaching highway sign, an image comes to fill a substantial portion of the viewer's field of vision, it will become more legible than when it was further

²⁰¹ Robert Venturi, Denise Scott Brown, and Steven Izenour, *Learning from Las Vegas: The Forgotten Symbolism of* Architectural Form, (Cambridge: MIT Press, 1977), 9. ²⁰² Tannenbaum, 18.

away and smaller.²⁰⁵ In general, Tannenbaum notes, the easier it is for the viewer to see the sign, and the more it is pushed to dominate their field of vision, the more likely they are to read it. According to Tannenbaum, legibility is simply a matter of "reducing the effort required" for a viewer to see a message.²⁰⁶ Tannenbaum cites the American Institute of Graphic Arts (1974 pp 120-129) in stating that "a useful rule of thumb is not to exceed a ten degree angle from the [viewer's] natural horizon plane."²⁸⁷

Other graphic elements also affect legibility — such as line clarity, typeface, color, and contrast. Increasing the legibility sometimes only seems to require common sense — a clean line will be clearer than a fuzzy line, a simpler sans-serif typeface will be more legible than an ornate typeface, and bright colors — such as yellow — will demand attention more than neutral colors. (Figure 24) Contrast between the figure and the ground also seems to be a major aspect of legibility. Increased contrast between the two generally results in increased legibility, although light figures on a dark ground are less legible than dark figures on a light ground. Legibility via contrast also extends to shape relationships — a large object among many small objects will attract the viewer's attention because it "stands out," it is different, and therefore, more noticeable. Spatial relationships between elements (such as type) affects legibility as well. If elements are too crowded together, they become illegible. The reverse is also true — if elements are too spread out, like the stones at Avebury, they will be more difficult to read, or in extreme cases, will not be perceived as a whole.³⁹⁶

Legibility is not always the sole factor at play in determining whether a viewer sees a message. Sometimes, as Tannenbaum points out, encouraging viewers to read a sign has more to do with aesthetics. Aesthetic harmony plays a role in that "the more elegant and appealing stimuli are selected over the less balanced, less harmonious, and poorly composed ones."²⁰⁹ The viewer is more likely to look at things that are appealing. This point seems to conflict with Brill's desire to create a viscerally repellent monument on the site. However, the property of aesthetic elegance could theoretically be applied to the denotative elements — the text, pictograms, and images — without vitiating the larger

²⁰⁴ Ibid.
 ²⁰⁵ Ibid, 19.
 ²⁰⁶ Ibid.
 ²⁰⁷ Ibid.
 ²⁰⁸ Ibid, 21.
 ²⁰⁹ Ibid.

connotative message of repulsion. Information graphics expert Edward Tufte echoes many of Tannenbaum's ideas in his writings on the clear presentation of data. Overall, he recommends doing the most with the least — legibility is aided when graphical elements are simplified to their essentials. "Often the happy consequence of economy of means is a graceful richness of information, for small differences allow more differences... data displays must be clean, assured, reliable, sturdy."²¹⁰

Tannenbaum concludes that the most significant development in perception of the past century occurred in the Gestalt school, and should be considered in forming the WIPP marker.²¹¹ The theory of the gestalt is built upon the notion that perception in an ongoing activity, and that incoming information can be presented to the brain in more or less digestible forms. The pragnanz principle, in particular, "holds that certain figures — essentially those with the properties of symmetry, regularity, and simplicity — are more readily recognized, more stable, and will be remembered more readily than others."²¹² Symbols and images possessing these qualities are considered "good figures." Because the intention of the WIPP's project is to aid in the collective remembrance of the dangers and location of the waste repository, a "good-figured" symbol should logically be used. As mentioned earlier by Kaplan, the radioactive trefoil symbol is good-figured since it has particular emergent properties that are greater than the sum of its parts. By examining different arrangements of the parts comprising the trefoil symbol, Tannenbaum demonstrates the mysterious allure of the "good figure." (Figure 25) The trefoil symbol stands out clearly from the other symbols, although all symbols are comprised of the same parts — black and white triangles and circles. The strong graphical impact of the trefoil symbol can be attributed to its symmetry, regularity, use of basic shapes, and strong contrast.

Legibility: A Case-Study

These same principles were used in the Department of Transportation's (DOT) *Symbol Signs* project in 1974. The project sought to create a set of universal nonverbal signs to be used throughout the United States transportation system. According to Meggs, the aim of these symbols is to "communicate important information and directions quickly and simply."²¹³ Thus the goal was not to merely communicate information to a wide cross-section of message-recipients, but to do so in a

²¹⁰ Edward Tufte, *Envisioning Information*, (Cheshire, Connecticut: Graphics Press, 1991), 73.

²¹¹ Tannenbaum, 23.

²¹² Ibid.

²¹³ Phillip B. Meggs, *A History of Graphic Design*, 2nd ed. (New York: Van Nostrand Reinhold, 1992), 381.

manner which facilitates the flow of traffic. Through increased legibility, the *Symbol Signs* are able to more efficiently direct travelers to their desired routes, eliminating the need to slow down or stop. Although the WIPP signage project does not involve such stringent time-requirements — it is more important that the message be read at all than to be read in an time-efficient manner — time is always an issue. There is a common sentiment in the field of graphic design that if the message can be easily read, it will be read. Viewers will naturally read along the path of least resistance, when faced with a variety of seemingly similar messages. The WIPP site will benefit from its unique nature, since it will presumably lack competing messages of a similar ilk. However, even within this unique message environment, time-pressure remains a factor. The site will not function to direct traffic on a second-by-second basis like the *Symbol Signs*, but it will need to successfully in divert activity away from the interred hazard. In a scenario where the site has been ignored over a long period of time and rediscovered by a developer wanting to dig, the message must be deciphered over a timeframe of months or faster — rather than years — in order to successfully prevent digging. Thus, complex signage that may provide more detailed information may also stray from the central tenet of the project by reducing the sign's effectiveness.

Although the *Symbol* Signs project undeniably differs in its time-requirements and audience, it is similar to the WIPP project on a fundamental level. Both message systems attempt to bridge the barrier of language to communicate a specific message that affects the actions of the message recipient. Because of this commonality, and because of the ultimate success of the *Symbol Signs* project, it is worthwhile to investigate how the project was organized and how signs were developed for legibility.

The technical report published by The American Institute of Graphic Arts (AIGA) in cooperation with the US Department of Transportation (DOT) outlines how the signs were developed by committee.²¹⁴ Dividing the DOT's signage needs into thirty-four areas, researchers sought parallel examples of sign types from all around the globe. In a few cases, these preliminary examples were deemed effective enough to make it into the final *Symbol Signs* group, but most of the glyphs were altered or completely remade according to the AIGA's criteria. Achieving a sense of harmony and balance was a main objective of the project, concurrent with the 'path of least resistance' notion that what is easy to look at, will be seen. Meggs writes that, "Clarity of image was their overriding goal ---the resulting symbol system combined overall harmony with a visual consistency of line, shape, weight, and form."²¹⁵ Presuming that these "formal values" are universal — at least within the perceptual preferences of the current world population, Meggs follows with this statement, "This effort represented an important first step toward the goal of unified and effective graphic communications transcending cultural and language barriers in a shrinking world."216

An extremely sophisticated method for evaluating the preexisting transportation symbols was developed by the team, wherein each team member would independently fill out a ballot evaluating each symbol's strengths and weaknesses. Each symbol was evaluated on its Semantic, Syntactic, and *Pragmatic* strength, properties which the team considered common to all forms of visual communication. The report notes that these three components interrelate in complex ways. The team therefore abstained from considering them as wholly separate elements.²¹⁷ They defined each of these "basics of communication" in their report:

The semantic dimension refers to the relationship of a visual image to a meaning. How well does this symbol represent the message?... Do people from various cultures misunderstand this symbol?...Has this symbol already been widely accepted?218

The semantic effectiveness of a sign is perhaps the most challenging aspect to secure, since the same symbols can convey different meanings in different cultures (such as the swastika symbol). Some symbols are only effective because they are rooted in objects common in many places around the globe. Examples include the "universal" sign for telephone, which resembles a public telephone handset or the sign for mail, which pictures an envelope. (Figures 26 and 27) However, if the objects that the symbols reference disappear into obsolescence, the symbols may lose their original meaning. An additional syntactic factor considered during the evaluation process was the basic form necessary to denote meaning and eliminate any extraneous design elements from the symbol.

²¹⁶ Ibid.

²¹⁴ American Institute of Graphic Arts. Symbol Signs: the development of passenger/pedestrian oriented symbols for use in transportation-related facilities. (Washington: Dept. of Transportation, Assistant Secretary for Environment, Safety and Consumer Affairs, Office of Facilities, 1974), 1. Meggs, 381.

²¹⁷ American Institute of Graphic Arts, 11.

²¹⁸ Ibid, 12.

The syntactic dimension refers to the relationship of one visual image to another... How well do the parts of this symbol relate to each other? How well does this symbol relate to other symbols? Is the construction of this symbol consistent in its use of figure/ground, solid/outline, overlapping, transparency, orientation, format, scale, color and texture?... Are the most important elements recognized first? Does this symbol seriously contradict existing standards or conventions?²¹⁹

The syntactic considerations are somewhat simpler to control, since they focus on issues internal to the form of the symbol, rather than predicting the unquantifiable visual vocabulary of global culture. However, unhelpful to the WIPP project will be the team's inability to keep the symbol consistent with the formal conventions of the future — they will be impossible to predict today. Although some formal elements have remained consistent over long periods of time, a gradual shift in signification is already perceptible. Importance, for example, is often shown through a hierarchy of size relationships, wherein larger messages or signs are considered by the viewer to be the most important. However, it also seems as if this preference can be unlearned. People learn to "tune out" unwelcome messages, and in our age of well-funded advertising, the largest messages in the urban landscape are often the most banal. If this trend continues, a reversal in our perceptual preferences of size may occur, wherein viewers learn to prioritize smaller more personal messages over blaring advertisements.

The pragmatic dimension refers to the relationship of a visual image to a user. Can a person see the sign? Is this symbol seriously affected by poor lighting conditions, oblique viewing angles, and other visual "noise"? Does this symbol remain visible throughout the range of typical viewing distances?²²⁰

The pragmatic aspects of symbol design primarily involve issues which would be pertinent to environmental graphic design and be considered by someone like Brill. The issue of size, placement, and lighting must all be calibrated relative to the flow of space and expected viewing conditions.

An example of how the evaluation process worked is shown in Figure 28. This example shows the evaluation of preexisting universal symbols indicating the location of a payphone. The samples were collected from a variety of sources, spanning many types of facilities from around the globe. One

²¹⁹ Ibid.

63

is taken from Sweden's National Parks System (NPS), while another was created by the Port Authority of New York and New Jersey (PORT). The twenty symbols were then assigned a number rating by the team members according to their semantic, syntactic, and pragmatic effectiveness. Based on the results of the number ratings, as well as the overall concerns of the team, symbol design recommendations were made. In the case of the telephone symbol, the team members lamented that none of the handset designs were completely satisfactory. In their comments, they worry that such an awkward shape lends itself to ambiguity, and might be mistaken for another tool, such as an automotive wrench. However, since there is little variance in the form of the handset design, and since it accurately represented the appearance of a pay telephone, the design team concluded that this 'nonideal' shape had already come to internationally represent the telephone. It should therefore be accepted as a basic model in their redesign process.

As mentioned earlier, and as represented in the example of the telephone symbol, many of the symbols communicate by referencing an object associated with the meaning of the symbol. In this case, a telephone handset can represent the concept of "place to make a call" or "payphone." However, in their report, the team notes that symbols can communicate concepts in ways other than by simply representing objects already familiar to the general public. The first aid symbol and the "no entry" symbol are cited as abstract non-referential symbols which have become convention.²¹ However, they have only made their way into common knowledge because of widespread education — i.e. there is nothing inherently "medical" about a red cross, but it has been widely accepted and recognized as the symbol because people have been told what it means. Of course, this type of abstracted symbol/meaning relationship would not be effective in the WIPP project, where the creators of the symbol could not possibly educate their descendents, 10,000 years down the line, on the meaning of an invented symbol. Inversely, all of the symbols so succinctly outlined by the *Symbol Signs* project would fail banning a widespread cognizance of the referenced object.

However, the team's third message type, which depicts an illustration of transaction, may be useful to the WIPP project. These types of symbols are more complex and less streamlined (making them less attractive for modern purposes). However, due to their illustrative nature, they may be more

²²¹ Ibid, 83.

successful in communicating to the completely uninformed viewer. The "ticket purchase" symbol developed by the team is an example of this strategy. It clearly shows a transaction between two individuals. Even if the viewer does not understand what a ticket "is," he or she will be able to understand that a transaction is taking place between two individuals — the context of place should then fill in the gaps to let the viewer know what is being transferred.

In their conclusion, the team contradicts their faith in the readability of good gestalt, evidenced by their laborious studies and simplification of form.²²² The report notes that it "is quite difficult to objectively predetermine the effectiveness of any one symbol... constant repetition has more to do with effectiveness than does a difference in the style of drawing or appropriateness of concept."223 However, in the WIPP's design process, all abstract (non-referential) symbols were immediately disqualified from the selection process, regardless of their proven effectiveness. Because nonreferential symbols were considered to be lacking in inherent meaning, all abstract symbols were immediately dubbed by the team as 'non universal.' However, there is a flaw in this logic since, on a larger timescale symbols grounded in ephemeral objects risk losing their physical referent, while abstract symbols do not carry this risk. When envelopes are no longer used to send mail, will the Symbol Sign indicating "Post Office" still be effective? The particular example of the abstract multiuse 'no' sign provides a compelling example of an abstract sign with deeply rooted associations in the human brain. The symbol consists of a circle which functions to delineate the symbol area, a referent to the prohibited activity (represented by its own symbol or illustration), and a strike-through mark to express negation. Although the strike out (or scratch out) mark does not directly reference an object, the use of the strike/scratch mark is debatably universal in its representation of the negation. This type of discussion is outside of the scope of the Symbol Signs project, but would be important in determining whether non-referential signage should be used in constructing the WIPP warning system.

²²² "Simplification of the images is one characteristic that makes the set of symbols a coherent group. The amount of detail used in the drawings has been reduced to a practical minimum. Unimportant features have been eliminated, resulting in a set of symbols that are consistently bold and direct. This characteristic boldness is also important if the symbols are to function as signs in busy confusing environments where unnecessary details would reduce legibility. The edges of many of the forms have been softened with curves to create contours that are distinctive and help to establish visual relationships throughout the group of drawings. The symbols were all drawn to function as dark figures on a light background." (American Institute of Graphic Arts, 83)

²²³ American Institute of Graphic Arts, 133.

Chapter Four: The Present and Future Landscape of the WIPP

The Present

Considering the facility's purpose, the current facade of the WIPP site is remarkably prosaiclooking. (Figure 29) The site's 16 square miles consist of desert and a smaller 1.5 mile fenced-in square in the middle which resembles an office park — filled with the quiet exteriors of white anonymous buildings.²²⁴ It is not as "top-secret" as one might expect either — civilians can easily download satellite images of the site using Google Maps (maps.google.com).²²⁵ (Figure 30) Not surprisingly this unexpected level of accessibility can be attributed to a piece of legislation mandating accessibility — namely, Title 3 of the Superfund Amendments Reauthorization Act, which includes the "community right to know" stipulation.²²⁶ The only visual element on the landscape that hints at the truly treacherous nature of the site is a small set of signs that dot the fences surrounding the facilities. On their faces, these signs bear messages such as "Contaminated Person Area" and "Staging Area for Potentially Contaminated Personnel."²²⁰ (Figure 31)

What makes the site extraordinary is what lies underground. 2,150 feet underneath the surface, is an incredibly complex maze of passageways.²³⁸ These passageways, carved out of the strata of rock salt comprising the Saludo Formation, occupy a total area of 2,064 by 2,545 feet — some experts expect this to be expanded as the need for the storage of nuclear waste grows.²³⁹ Linked to the surface by four main vertical shafts which bring the waste (and the workers handling the waste) underground, are the passageways, each 13 feet high by 33 feet wide, which will house the waste in sepulchral darkness for the next 10,000 years.²³⁰ (Figure 32) Tom Vanderbilt, who visited the site in 1998, shrewdly describes the interred site as the "tomb of the Cold War, where the peripheral apparatus that helped create the century's weapons of mass destruction will be interred over the next three decades."²³¹ (Figure 33)

Vanderbilt notes the irony inherent in the site — that nature, the very element threatened by the waste, will act as the protecting agent, buffering humanity from the same toxic materials it creates.²³²

²²⁴ Goodenough, 221

²²⁵ Google Maps, "Satellite," Google, http://www,maps.google.com.

²²⁶ Pasqualletti, 4.

²²⁷ Vanderbilt, 190.

²²⁸ Pasqualetti, 4.

²²⁹ Goodenough, 221

²³⁰ Pasqualetti, 4

²³¹ Vanderbilt, 185.

²³² Ibid, 186.
The protection comes via unfathomable mass — by virtue of the solid salt rock walls which isolate the underground tomb, seeming to stretch endlessly in every direction. On his tour through the burial chambers, one miner told Vanderbilt, "That wall is solid for 300 miles. There's no way you're gonna *Shawshank Redemption* yourself out of here."²³³ And in time, the whole area will be solid again. As nuclear radiation slowly melts the salt, which will slowly creep and encapsulate the 400,000 containers of transuranic waste that the facility was constructed to accommodate.²³⁴ Vanderbilt describes the "creep" which has already begun to take place: "In Room 6…the ceiling noticeably droops, and the floor has begun to arc upwards…the salt walls soften the light, bathing the room in a glow that just as well might be coming from ice."²³⁵

Where does such an environment get its origin? DOE public official, Ken Aragon explains that the excavation activity began as mining activity. Miners left a complex of tunnels in the region so extensive, that many remote locations in the desert are connected underground.

[People] have been mining here since the mid-thirties, twenty-four hours a day, three-hundred sixty-five days a year. There must be thousands of miles of tunnels.²³⁶

The Future

With any luck, the underground portion of the WIPP site will look roughly the same — if a bit melted — by the year 10,996 AD. However in the event that one of the Markers Panel's design proposals is chosen, the current office park facade of the WIPP will undergo quite a facelift. The Markers Panel members agreed that the best way to keep people away from the site will be to make the site inhospitable to people. While making the site actually dangerous to people is in opposition to the enabling legislation (and the nature of the project), the site should at least project a sense of danger. The site will therefore be made to look as ominous as possible.

The Markers Panel was culled together by Sandia National Laboratories in November of 1991 to synthesize predictions of the ecological future of the region with the Future Panel's predictions on the

²³³ Ibid, 187.

²³⁴ Pasqualetti, 4.

²³⁵ Vanderbilt, 187.

²³⁶ Ibid, 191.

socioeconomic future of the region.²³⁷ Working together in an interdisciplinary environment, the teams produced several possible designs for the warning marker, which vary greatly in both scale and approach. Maureen Kaplan describes their work environment:

Mike Brill arranged for us to spend the time at beach cottages on Lake Erie in the dead of winter...Mike (of blessed memory) also thought with a pen in his hand and sketches took shape with stunning speed (at least to me, since I can't draw at all). I brought a laptop and tried to capture ideas as they flew around the table. I summarized them after the first day and we went over it the next morning, both to correct it and to get back into the brainstorming mode. Woody Sullivan brought the attitude of "I'm working on the search for extraterrestrial intelligence. If I can't figure out how to communicate with my own species over 10,000 years, then what am I doing?" Fred Newmeyer played devil's advocate with most ideas till we shook them out to something reasonable. Ward Goodenough, having worked in Yap and other places in Micronesia, kept us honest in keeping different outlooks. If we hadn't gotten anything recorded at the time, the ideas may well have evaporated into the mist... The team approach was much more productive than the individual efforts in the Human Interference Task Force in the 1980s. We had the material scientist thinking "what's durable"? and coming up with titanium as a marker material. The archaeologist jumped up and down at the suggestion--"yes, titanium is durable but it will never survive. It will be recycled as soon as you turn your back on it!!!" We hashed all those arguments out in the brainstorming session so Sandia [National Laboratories] didn't get conflicting input. 238

Given the diversity of the teams, and the active and interdisciplinary work environment, it is not surprising that the project failed to produce a single, monolithic design proposal.²²⁹ The differences in opinion among team members led to alternate design directions. A total of eight distinct design approaches were developed to solve the warning marker problem. Despite this apparent pluralism, the teams' final report contends that "there is much consensus on the design criteria and necessary

Team B:

• Wendell Williams (Case Western Reserve University, Materials Science & Engineering) (Sandia National Laboratories, 1.)

²³⁷ Sandia National Laboratories, 1.

²³⁸ Maureen Kaplan, interview by author, 10 September 2005, Lexington, MA, email correspondence.

²³⁹ The report also provides a listing of each team member, the institution with which they are affiliated, and their field of expertise:

Team A:

Dieter Ast (Cornell University, Materials Science & Engineering)

Michael Brill (Buffalo Organization for Social Technological Innovation, Environmental Graphic Design)

[•] Ward Goodenough (University of Pennsylvania, Physics & Astronomy)

Maureen Kaplan (Eastern Research Group, Archaeology)

Frederick Newmeyer (University of Washington, Linguistics)

Woodruff Sullivan (University of Washington, Astronomy)

[•] Victor Baker (University of Arizona, Geology & Hydrology)

[•] Frank Drake (University of California at Santa Cruz, Astronomy & Astrophysics)

[•] Ben Finney (University of Hawaii at Manoa, Anthropology)

[•] David Givens (American Anthropological Association)

[·] Jon Lomberg (Independent Artist, designer and writer)

[•] Louis Narens (University of California at Irvine, Cognitive Science)

components of the marking system," indicating that the noted differences of opinion were minor.240 The sketches drafted by team leader Michael Brill are reprinted in both the design teams' final report - Expert Judgment on Markers to Deter Inadvertent Human Intrusion into the Waste Isolation Pilot *Plant* — and a report released by Brill's company, BOSTI, entitled Site Design to Mark the Dangers of Nuclear Waste for 10,000 years. Before the sketches were created, the teams created an allencompassing list of design guidelines.²⁴¹ Their process vacillated between fanciful musings on how the person of the future would "read" different visual cues, to a rigid and strenuous process of forming design guidelines. During the process of creating the design guidelines, the team focused on how the design must perform, rather than defining specific material stipulations.²⁴² Ignoring the specific details of appearance, they focused instead on what the design should "do."

The guidelines, as applied to the final sketches, serve as the final conclusions reached by the design teams. The teams structured these guidelines to be flexible — "they describe how the design must perform, rather than what it must look like or be made of" — granting the builders some degree of flexibility in devising an optimal construction solution.²⁴ The guidelines range from criteria required by the enabling legislation — "the site must be marked" — to specifications of the scale of the individual components of the marker to the whole marker system.244 These guidelines reflect a specific choice made by the design teams to make the site viscerally repellent. The marker structure, whatever its form, should avoid projecting any sense of "shelter or nurturing." Since team leader Michael Brill created the design sketches, it is not surprising that many of his aforementioned archetypal ideas are used to project this sense of forbidding space. In accordance with Brill's vision, the teams' final report states that, "The designs utilize archetypal imagery whose physical forms embody and communicate meaning."245 Many of the designs borrow their form from "images of dangerous emanations and wounding of the body."²⁴⁶ Other forms extend a repellent message by

²⁴⁰ Ibid.

²⁴¹ Excerpts, 4.1. (See Appendix A for full list of guidelines, the basis and discussion for each of these guidelines has been discussed earlier in this paper.)

²⁴³ Ibid.

²⁴⁴ A full listing of these performance-based design guidelines appear in Appendix A.

²⁴⁵ Sandia National Laboratories, 4.2.

²⁴⁶ Ibid.

making the land extremely inhospitable and uninhabitable. Unless otherwise stated, all surface marker designs are accompanied by additional Level III and IV messages which are buried underneath the site. <u>The Design Sketches</u>

The first design mentioned in the team's final report, titled "Black Hole," covers the entire two square mile area of the repository with a giant black slab of stone. (Figures 34 and 35) The color would derive from the type of stone used — either black basalt, granite, or black dyed concrete. This sort of structure would render the earth "useless" to humans — preventing both farming and habitation. The area above the repository becomes a void, a vast piece of nowhere. This sort of structure may invite the interest (and scientific investigation) of future communities, but would make development of the area impractical. This design also fulfills the function of appearing aesthetically ominous quite well — lending an excessively "dead" look to the location. "It is a massive effort to make a place that is frightful, ugly, and uncomfortable."247 The physical discomfort of this desolate environment is escalated by the desert heat. During the sunny days the black slab will absorb the full spectrum of light rays into its surface, resulting in a slow, steady outpouring of heat onto its surface. The already hot 92.8° F average temperature of the desert will be amplified, creating a hot, burner-like surface that is inhospitable to all forms of life. Benford notes that this increased heat may even reduce surrounding vegetation, making the land even more inhospitable to life.²⁴⁸ Since the slab will constantly be giving off heat, the site could easily be detected from the air at night by its infrared emission. Because the intense heat "will generate substantial thermal movement" expansion joints need to be built into its structure to avoid cracking.²⁴⁹ Using a system of irregularly-shaped "crazy quilt" expansion joints would make it more difficult for the material comprising the slabs to be reused. The lack of symmetry of the "crazy quilt" design does not appeal to the natural human attraction to good gestalt, balance and order. This sort of design strategy divorces the area from a sense of human logic and human workmanship. The pattern of irregular expansion joints will also resemble the craquelature pattern that results when land becomes excessively parched and dry.²⁰ The team also suggested that the slab not be

²⁴⁷ Ibid, 4.2.

²⁴⁸ Benford, 67.

²⁴⁹ Sandia National Laboratories, 4.2.

²⁵⁰ Ibid.

completely flat, but rather subtly undulate, "so as to shed sand in patterns in the direction of the wind."²⁵¹

The second proposed design, entitled "Rubble Landscape" resembles the Black Hole design in its general form. (Figure 36 and 37) It blankets the 2-mile square area of the nuclear storage facility with a gigantic foreboding square. The space within Rubble Landscape is made treacherous by virtue of its aggregate parts — rather than its ability to absorb heart. The outer rim of the square will be bulldozed down to the caliche layer of stone. This creates a sort of sand "moat" which surrounds the large pile of bulldozed rubble. The rubble makes the space difficult to walk on or to bring machinery onto, thus discouraging development of the land. Because of the process used to create the rubble, the individual rocks will naturally be irregularly shaped, discouraging the reuse of the rocks as building material. The Rubble pile will rise slightly above the rest of the desert, creating a visual anomaly to further demarcate the poisoned land. The team intended that it be "…a place that feels destroyed, rather than one that has been made."⁵⁵² However, the geometric moat which forms the perimeter of the rubble-landscape will preserve the Level I message that "man made this structure."

The third proposed design, Spike Field, gives the impression that danger threatens the viewer from below. (Figure 38 and 39) Eighty-foot high basalt spikes rise from the earth at varying angles. Irregular and non-repetitive in their shape, location, and orientation, they express a sense of chaos and unease. These spikes would be dispersed throughout the entire space to denote the repository area. The shape of the spike was chosen because it is a threatening form in the natural world. It is a form that wounds the body, and it thus signifies danger on a very fundamental, visceral level.

The fourth proposed design, Spikes Bursting Through a Grid, utilizes the potent form of the spike while accentuating the idea of danger as an upward thrust from below. (Figure 40 and 41) These wounding forms appear kinetic, as if they are growing up out of the ground in unpredictable directions. The spikes destroy order as they disrupt the geometric grid, which has been laid over the desert earth. They cut through the grid as a spear or a stake would cut through skin.

The fifth design, Leaning Stone Spikes also belongs to this series of "wounding forms" designs. The spikes lean so as to appear precarious — giving the impression that they might fall at any moment.

²⁵¹ Ibid. ²⁵² Ibid. (Figure 42) The sheer mass of the leaning basalt or granite column implies movement by virtue of its threatening position. Brill, in his sketches, recognizes that this precarious placement will require much material reinforcement. Maintaining the tilted positioning over a span of 10,000 years will be quite a feat of engineering. In his sketches, Brill suggests that the spikes be anchored 15-20 feet underground, and that they be attached to a flat piece of footing — which can then be anchored securely into the rock strata. The slabs of rock comprising the spike form would also need to be securely joined together. Brill suggests using cylindrical keys through the core of the materials to join the pieces together lengthwise. The joints between the individual masses of rock would be particularly vulnerable to the intrusion of salts. Channels would need to be built to promote rainwater runoff away from the joints. Brill proposes that all of the stone-to-stone and stone-to-key connections assume a form conducive to the channeling of water. A continuous curvature along the surface would help channel the water outwards and off of the structure.

The sixth design sketch, entitled Landscape of Thorns presents a more densely crowded landscape — making intrusion impossible without injury. (Figure 43 and 44) Perhaps the most evocative and "science-fiction"-looking of the designs, the landscape of thorns would completely cover the two mile squared burial site with giant thorns growing out of spikes. This landscape would not only appear threatening, but would actually pose a physical threat to trespassers — who would risk impalement upon entering the marker.

The seventh design, entitled Menacing Earthworks, was a favorite of many design team members. Assuming the form of a giant earthwork, like Serpent Mound in Ohio, Menacing Earthworks would mark space through giant forms of raised, sculpted earth. (Figures 45-47) However, unlike the soft curves of the Serpent Mound, the site warning would be comprised of stiff zigzagging shapes which terminate in sharp points. Roughly lightning-shaped, the forms are irregular and asymmetrical, crowding the landscape and preventing the viewer from being able to see the horizon.²³³ The purpose of these 50-foot-high forms is to infuse the viewer's sense of the landscape with chaos, lending a sense of disorientation and "a loss of connection to any sense of place."²⁵⁴ Since earthworks are best viewed from the sky (lest they be mistaken for naturally-occurring hills), the design team proposed that four

²⁵³ Benford, 69.

²⁵⁴ Sandia National Laboratories, 4.3-8.

elevated berms be constructed at the four corners of the burial site. This way land-based viewers will be able to get a sense of the warning marker as a whole. From this vantage point, the viewer would see that the lightning-shaped earthworks line only the perimeter of the burial site, leaving the center of the site largely vacant. In the middle of this open courtyard, a large map of the world would cover the ground revealing the locations of other nuclear waste burial sites across the world. (Figure 48) The map would be slightly convex, so as to shed sand in the wind. A crosshair would be fixed on the viewer's exact location within a 50-foot wide map of New Mexico. Underneath the intersection of the crosshair, a concrete hot cell would be buried. This hot cell would contain enough small samples of the interred waste that even a basic Geiger counter would register its radioactive content. Underneath this hot cell would lie a room filled with Level IV messages.

The eighth design, entitled Forbidding Blocks, blankets the entire two mile square area with giant concrete blocks. (Figure 49 and 50) The blocks, approximately 25 feet long on each side, would be irregularly shaped to prevent reuse. Their arrangement however, would assume a highly geometric ordering — forming a huge grid. This ordered structure, far from accommodating a human aesthetic, can be seen as an extreme attempt to make the land uninhabitable. With only 5-foot-wide "streets" in between each block in the grid, the usable space remains too small to accommodate farming or living. It barely provides enough space to pass another person walking along the same "street" within the grid. It would only offer enough room for a claustrophobic stroll on a pathway that leads to nowhere but to other pathways. Like the Black Hole design, the Forbidding Blocks would be dyed black to increase sun absorption and the discomfort of trespassers. The site itself would serve as "a massive effort to deny use."²⁵⁵ Brill includes a variation on this original design, which incorporates the ideas of rubble landscape into the Forbidding Blocks design. This variation would consist of 25-foot square blocks surrounding a rubble core. Intrusion would be prevented though the use of sheer mass — it would require an immense effort to displace this amount of stone.

The team notes that the use of a buried Level IV room would be applied to any of the designs and will be particularly useful for communicating more sophisticated messages to future archaeologists. (Figure 51) The sliding stone "entry plug" would be large enough to crawl into, but small enough as to

²⁵⁵ Brill, 20.

prevent the removal of the large stone inscription slabs. The room would explain exactly what materials are buried at the site. A periodic table will be provided that highlights the elements comprising the interred waste. Multiple three-dimensional drawings would reveal a mapping of the entire complex of tunnels in the underground salt mines. From this, the viewer would be able to determine exactly where he/she stands in relation to the dangerous material. The Level IV room would also contain an astronomical calendar, which would explain (in the most universal terms available) how long the waste will remain toxic.

The team also recommends that an above-ground Level II and III message kiosk accompany all of the proposed markers. The kiosk would consist of one concave granite "message wall" faced by a larger concave "concrete protecting wall." (Figure 52) The granite wall, which would list Level II messages in the seven world languages of the United Nations, would be protected from wind and sand erosion by the larger concrete wall. Blank areas would be left at the bottom of the granite message to provide adequate space for future generations to re-inscribe the message in newer languages. On the walls of this kiosk, as well as the walls of the buried Level IV room (and perhaps also on the marker structures themselves) simple drawings illustrating the dangers of the site would be included.

Benford suggests that this type of pictogram be used to explain the hazards in more specific terms, while the monolithic marker designs communicate an abstract, but over-arching aura of disagreeableness.²⁵⁶ Design team member Jon Lomberg concurs with this sentiment noting that, "I looked at art over the last 5,000 years to see what was universal. What I came up with over and over again was the pictorial narrative, the comic strip."²⁵⁷ In the design team's final report, they suggest that simple drawings be inscribed on all monuments where they would be protected from the wind — such as within the criss-crossing aisles of Forbidding Blocks.²⁵⁸ Goodenough suggests that simple illustrations of faces showing horror and distress also be used alongside the international radiation symbol. This way, even if the meaning of the radiation symbol fades from cultural memory, facial expressions (which are the same cross-culturally) will be understood. The radiation symbol will then, theoretically, be associated with the emotions of horror and distress.²⁵⁹

²⁵⁶ Benford, 72.

²⁵⁷ Strauss, 19.

²⁵⁸ Sandia National Laboratories, 4.3-15.

²⁵⁹ Goodenough, 223.

Within the notes that accompany the design sketches, it is remarkable how many times the word "irregular" appears. All of the proposed designs, even the flat slab comprising Black Hole possess some aspect of irregularity. In regards to this, Benford notes that

The common ideas here are a forbidding prospect, irregular geometries, and anticraftsmanship. This contradicts human archetypes of perfection in our imperfect world, which circles, squares, and pyramids would echo. Using crooked forms when plainly the designers knew "better" suggests a deliberate shunning of the ideal, a lack of value here...People value craft, too, so these designs are roughly made, of materials such as rubble and great earthen mounds that discourage workmanship.²⁶⁰

In examining the design sketches and considering how they translate Given's system of communication levels, another trend emerges in terms of scale. Articulating the Level II ("danger!") message requires greater mass that communicating more complex, delicate messages. In order to send visceral messages, large striking forms must dominate the viewer's field of vision. Benford describes the anticipated cohesive impact of the site marker:

With the wind blowing through the monoliths, coaxing mournful acoustic resonances from their curves, a dissonant and wailing aura should surround the place. Whatever cultures come and go, they should inherit a legend of a spooky, disagreeable place...²⁶¹

Furthermore, since "...the site may pose a greater hazard than is officially acknowledged...this [the Markers Panel] panel recommends that the markers and structures associated with them be conceived along truly gargantuan lines."²⁶² The team notes that the scale of the project should at least match, if not surpass, the scale of the danger posed by the site. If nothing else, the scale of the markers should immediately announce the location's importance to any onlooker, regardless of their culture or era. The team remarked that much greater construction projects have been undertaken for less dire causes. For example, in the construction of the Panama Canal, 72.6 million cubic meters of earth was excavated and the Great Pyramid occupies 2.4 million cubic meters of space.²⁰³ The warning marker, if it is to be successful, will also have to be built on this grand scale. "In short, to ensure the

²⁶⁰ Benford, 73.

²⁶¹ Benford, 72.

²⁶² Sandia National Laboratories. 5.2.

²⁶³ Ibid.

probability of success, the WIPP marker undertaking will have to be one of the greatest public works ventures in history." ²⁶⁴

Still nothing — monumental or minute — will be built at the WIPP site until the year 2083.²⁶⁵ Between now and then, military personnel will actively guard the burial site while subsequent panels of experts meet and expand upon these initial design ideas for deep time communication.

²⁶⁴ Ibid.

²⁶⁵ R. C. Baker, "Deep Time, Short Sight," *Village Voice*, 47, no. 22 (2002), 43.

Chapter Five: Art for a Future Public

In spite of the design teams' attempt to account for the inscrutable amount of factors at play in designing for a future unknown public, the essential unanswerable question remains: How will the people of the distant future regard the marker? The ideal answer to this question, according to the design team's sketches, might be "with fear and repulsion." After all, the chief responsibility of the marker is to deter. Employing organic images of repulsion — threatening bodily harm — ensures a universal message that affects the viewer at a physical, subconscious level.

However, design team member Dieter Ast notes that aside from deterring human activity, the site holds a second responsibility — self-preservation. Barring this, the primary objective of the marker cannot be fulfilled. Typically, two factors threaten the longevity of monuments such as those proposed by the WIPP design teams. The first, weathering and salt-popping — resulting from the actions of nature — can be overcome (to some degree) by thoughtful design and sturdy construction. The examples of the Great Pyramids and the Great Wall of China provide invaluable opportunities to study nature's effect on materials over time, which helps to develop more permanent constructions.

However, the second threat to longevity, the actions of human beings, is a much less predictable source of damage. While the design teams discussed construction strategies that would prevent the marker from being salvaged for parts, they did not provide design provisions that would keep it from being torn down. In other words, they did not design it to appear intrinsically valuable as a monument. Dieter Ast writes in his final report that,

It is quite another matter to design a marker system that will for the next 400 generations resist attempts by individuals, organized groups, and societies to destroy or remove the markers. While this report discusses some strategies to discourage vandalism and recycling of material, we cannot anticipate what people groups and societies may do with the markers many millennia from now.²⁶⁶

This is where the WIPP marker begins to function less like a simple "keep out" sign and more like public art. A "keep out" sign simply deters — it holds no value to the deterred and overtime must be maintained by the individual who installed it. A work of public art, on the other hand, serves an aesthetic function in the public sphere — it contributes an aesthetic value to the community in exchange for maintenance. However, if a public work is seen as a nuisance or 'ugly', it is torn down. Dieter Ast writes, "Beauty is conserved, ugliness discarded."²⁶⁷ Part of the challenge of any public work or monument is to appeal to its public. Benford notes that, "The pyramids may have survived in part because they are striking, not just because they are bulky and hard to tear down."²⁶⁸

Unfortunate for the WIPP marker, is the long history of controversy provoked by public art. Team member David Givens notes that ,"If you go back into ancient history you find that one of the first things new regimes do is tear down the monuments of their predecessors."²⁶⁹ The sack of Rome by the Gauls in 387 BC is a prime example with countless monuments, both public and private, being destroyed.

The Destruction of Public Art: A Case-Study

In a more modern context, where public art is often used to "serve" a community rather than to simply glorify its leaders or represent the state's ideals, the process becomes more democratic. The public gains a heightened degree of control in deciding whether public art stays or goes. In this context, public art is interpreted strictly as "art for the public" — only living up to its title when it is embraced by a majority of the surrounding community. Predictably, this brings about the untimely destruction of many public works perceived by the public as "ugly." Hawthorne, in his article entitled *Does the Public Want Public Sculpture*?, attributes this phenomenon to the selection process — which is usually led by arts professionals rather than a representative sampling of the public.²⁷⁰ Regarding the ample controversy raised by several pieces of public art erected by the National Endowment for the Arts' (NEA) Art in Public Places Program, the NEA's Freudenheim remarked that the selection process isn't — and shouldn't — be controlled by the masses, but by arts experts. He stated,

Just because I go to a baseball game does not mean I should choose the team. Only when it comes to art does everyone think that the man on the street should have a say — that's a misunderstanding of democracy.²⁷¹

²⁶⁶ Sandia National Laboratories, 5.6.

²⁶⁷ Ibid.

²⁶⁸ Benford, 82.

²⁶⁹ Strauss, 18.

²⁷⁰ Don Hawthorne, "Does the Public want Public Sculpture?," *Art News*, 81, no. 5 (1982), 60.

His point of view is vindicated on an economic level (the General Services Administration's (GSA) public art commissions boast a 400% increase in net value), as well as a logistical level (consensus amongst the entire public would be very difficult to achieve). However, it is ultimately the public who will have to live with the work on a day-to-day basis.²⁷²

And it is often the public, not non-profit art organizations, who have the final word on whether a work remains standing. Unique in the controversy that it provoked, Richard Serra's *Tilted Arc* provides an extreme example of what can happen when the public disapproves of a piece of public art. *Tilted Arc*, a monumental 120-foot-long piece of curving Cor-ten steel, was removed from its intended context — in front of the Javits Federal Building in Lower Manhattan — in 1989, eight years following its original installation due to public outcry over the sculpture.²¹⁰ (Figure 53) However, what is still unclear concerning the controversy and ultimate destruction of *Tilted Arc* is if a majority of the public was actually in favor of destroying the sculpture or if it was simply a very vocal and powerful minority. According to the documents amassed in the book *The Destruction of Tilted Arc: Documents* — out of the 10,000 people working in the Javits Federal Building, only 3,791 signed a petition urging the sculpture's removal.²²⁴ Adding to the confusion is the March 1985 public hearing. There lies a discrepancy between the number of people testifying in favor of retaining the work and the final ruling. Despite the fact that 122 of the 180 speakers favored retaining the work, the hearing panel voted to destroy the work. Obviously, more complex political factors were at play in the decision to destroy *Tilted Arc* than the voice of an outraged public.

Precisely what caused the public (or rather, a percentage of the public) to so hostilely protest *Tilted Arc*? Was the outrage provoked by something inherent in the sculpture's form? Or was the disapproval merely the result of political factors (and matters of taste associated with political factors)? Within the documents collected for *The Destruction of Tilted Arc* is a 'representative sampling' of speeches from the public hearing. Eleven of the 58 negative speeches are reprinted in the book. Many of the speakers show animosity towards non-representational work in general, such as Harry Watson, who referred to the work as "a rusted metal wall" and suggested that it should be sold "to a scrap metal

²⁷¹ Hawthorne, 62.

²⁷² Ibid.

²⁷³ Ibid, 56.

farm for maybe fifty dollars."²⁷⁵ His sculptural ideal was embodied by the adjacent examples in City Hall Park — namely the figurative examples representing Benjamin Franklin, Nathan Hale, and Horace Greeley. *Tilted Arc* conflicted with his idea of what a sculpture should be. Another speaker protested that , as a genre, minimal art is dehumanizing — including *Tilted Arc*.²⁷⁶

However, many of the individuals protesting the sculpture, claim that the problems with the work transcend issues of taste. For example, Vickie O'Doughery, a security specialist in the building, believed that the work fomented criminal activity.²⁷⁷ The shape of *Tilted Arc* resembles that of a blast wall, the purpose of which is to vent an explosion upward. There was much fear of bombings, and she argued that it would be unwise to leave the sculpture in its current orientation — where it could easily be used by terrorists to redirect the force of an explosion upwards into the office building. Because *Tilted Arc* shields from view the activities of people on the side opposite the building, that it is a magnet for graffiti, and by blocking the view from the federal building, people on the other side could participate in illegal activity, such as drug dealing.

The majority of the speakers, while not willing to pass judgment on the sculpture's value as a work of art, claimed that it negatively affected the feeling of the public space in front of the Javits building. Speaker Margo Jacobs writes that, "I realize that my views or anyone's views of the sculpture presently occupying the plaza are subjective and personal, but what we are meeting to discuss is not whether or not we like the sculpture, but what the sculpture's effect is on the public and the plaza..."²⁷⁸ Many speakers complained that it prevented the public from fully using the space of the plaza, such as Representative Theodore Weiss:

The sculpture cuts a huge swath across the center of the plaza, dividing it in two, and acting as a barrier to the building's main doorways. Access to the building is awkward and confusing, and the normal walking patterns of those who enter and exit the building are disrupted. *Tilted Arc* rends the serenity of the plaza and obliterates its vista...²⁷⁹

²⁷⁴ Clara Weyergraf-Serra and Martha Buskirk, ed., *The Destruction of* Tilted Arc: *Documents*, (Cambridge: MIT Press, 1991.), 9.

²⁷⁵ Ibid, 120.

²⁷⁶ Ibid, 121.

²⁷⁷ Ibid, 117.

²⁷⁸ Ibid, 124.

²⁷⁹ Ibid, 115.

Another speaker writes "the plaza is now severely limited, preventing use by the occupants and the neighboring community for ceremonies, cultural attractions, and other recreational activities."²⁸⁰

What is noteworthy about the complaints (or at least the ones that are not ostensibly provoked by an anti-modern art aesthetic) is that they could be describing the WIPP design sketches. The specific spatial relationships objected to by the detractors of *Tilted Arc* are all formal elements present in one or all of the proposed WIPP sketches. The way in which the sculpture blocked space — preventing the free movement of people in the plaza — would certainly function in a similar way to the Forbidding Blocks design which limits freedom of movement to it five-foot-wide alleyways. Also, speakers complained that the sculpture seemed dangerous — much like the positioning of the Leaning Stone Spikes design, intended to lean precariously over the viewer. Another criticism of *Tilted Arc* — that it cuts the viewer off from his environment, creating a disorientating experience of space sounds like the description for the Menacing Artworks design. Furthermore, one of the foremost complaints — that *Tilted Arc* was merely a rusty object, lacking craftsmanship — closely echoes the WIPP design guideline that the site marker lack craftsmanship. Since

...people use good craftsmanship on things they value. In most of our schemes, the structure that cover or define the Keep's [or area directly covering the interred waste] "cover" are made crudely, or of materials that prohibit workmanship (such as rubble, or earthworks, or a large slab)... It speaks of a massive investment, but one not tinged with pride and honored with through-workmanship.²⁸¹

The team members felt that the use of excellent craftsmanship would supersede the effect of the threatening design elements — making the space much more inviting than repelling.

Perhaps the most obvious similarity between *Tilted Arc* and the proposed WIPP site marker is that they are both site-specific projects. Since the location of the work plays a large role in the creation of site-specific pieces, removing the work from the site destroys, or at least severely compromises it. Artist Richard Serra, in arguing against the relocation of his *Tilted Arc*, stated

I make works that deal with the environmental components of given places. Scale, size, and location of my site-specific works are determined by the topography of the site, whether it is urban, landscape, or an architectural enclosure. My works become

²⁸⁰ Ibid, 112.

²⁸¹ Sandia National Laboratories, 4.3-15.

part of and are built into the structure of a site, and often structure, both conceptually and perceptually, the organization of the site.²⁸²

Site-specificity puts the work into a uniquely inflexible position. If the space occupied by the work is repurposed, the work will be destroyed. If the work is removed from its original location or if the original location changes, the work will be destroyed. This is especially true in the case of the proposed WIPP site markers — if the marker is removed from its original location, the nuclear waste goes unmarked and the whole purpose of the marker is undermined.

The same spatial devices and design features, which were employed by the WIPP to be repellent were also perceived as universally negative design elements by the detractors of *Tilted Arc*. Whether the speakers were correct in their perception of threatening elements in *Tilted Arc*'s design — or whether they were simply trying to augment their largely subjective arguments with design "facts" — is another matter which is outside of the scope of this report. However, the correlation between what *Tilted Arc*'s detractors found objectionable and the WIPP's performance-based design guidelines suggests something more than a simple coincidence. It strengthens the idea that human beings, although far removed from our primal origins, are still sensitive to nuances of space and form, especially those which denote the possibility of physical harm. *Tilted Arc* succeeded in repelling spectators , it seems as if the team's theories concerning images of repulsion have passed their mock trial.

These similarities between *Tilted Arc* and the WIPP design sketches touch upon formidable riddle, one which was only mentioned in the final page of the design team's report. *Tilted Arc*, although successfully repelling (at least some) people from the Javits Federal Building plaza, was torn down. The WIPP marker, although it will require more than a crane and work crew, will also risk being torn down if it is perceived as threatening to its public. Design team member Dieter Ast writes that, "A marker system should be chosen that instills awe, pride, and admiration, as it is these feelings that motivate people to maintain ancient markers, monuments and buildings."²⁸³ However, designing the site to be attractive or valuable to the public contradicts the first role of the marker — to deter. Thus, how can the marker be made to deter and inspire awe at the same time?

²⁸² Weyergraf-Serra, 65.

²⁸³ Sandia National Laboratories, 5.6.

A Nuclear Waste Marker as Public Art

The question also remains whether or not the WIPP marker should be considered "art" at all. Jeffery Kastner, writer for *Public Art Review*, did not hesitate to include his article on the WIPP marker site in an issue devoted to time-based public art. Because of the deep time requirement, the markers must carry the message like public artworks carry messages, not like road signs carry messages. Its initial (Level I and II) methods of communication more closely resemble the emotional, non-literal communication strategies of works of art. The WIPP site would essentially serve as a public service announcement, spelled out in aesthetic vocabulary.

Some team members feared that if the WIPP marker is confused for art that the "warning" aspect of the project will be undermined. Team member Jon Lomberg remarked that

Even if we could commission some monument great enough to become a wonder of the world whose fame would be carried down through three hundred generations, the very fact that the marker was so impressive could lead to the belief that the purpose of the marker was artistic rather than communicative.²⁸⁴

Furthermore, Lomberg suspects that if the marker is considered to possess artistic virtue, the remote Carlsbad desert will instantly be transformed into a tourist area. Since people will want to travel to the marker, businesses catering to the needs of travelers might sprout up adjacent to the marker. The businesses will need to drill for water, and might disturb the underlying waste in the process.

However Brill considers this an unlikely scenario, and welcomes the idea of the site becoming a tourist attraction. According to Brill, a continuous lineage of people visiting the site "is one way of retaining a social memory."²⁸⁵ A sustained interest in the site would keep discussions of its purpose — and of the concept of nuclear waste — alive. He notes that there is probably no other way to keep the waste isolated — that all physical barriers can and will be overcome with time and technological advancement. The "symbolic barrier" created by the marker is the only hope in keeping the waste quarantined. This barrier can only be sustained if it is not ignored — that is, if people take an interest in the marker and its meaning. The example provided by *Tilted Arc* also supports his theory. Those speakers at the public forum who called for *Tilted Arc*'s removal generally did not take interest in the

²⁸⁴ Benford, 83.

²⁸⁵ Ingalls, B5.

piece as a work of art — they thought it was garbage. Thus, if the WIPP marker presents itself as an intentional piece of art (as well as an emotionally-expressive, threatening entity) it may stand a greater chance for survival.

Slippery Communication

The WIPP marker itself must alone accomplish the task of connecting its physically-articulated message of the present with the translators of the future. It is, first and foremost, a piece of communication. Thomas Sebeok remarks that one of the functions of communication is to bind distant times together.

It is generally believed that the social function of communication is the ensuring of continuity in society through access to the experiences and ideas of the past, expressed in (loosely speaking) symbols for transmission across space and through time. This is the 'time-binding' function of social communication. The time-binding ability of human beings arises from their usage of language, number, gesture, picture, and other symbolic forms enabling then to transcend the limitations of inherited characteristics and the seemingly insurmountable barrier of time."²⁸⁶

Throughout his report, Sebeok stays with this initial assessment — that communication is capable of overcoming vast barriers of time. However he concludes his report by acknowledging that there exists no "fail-safe method" for communicating 10,000 years into the future. He nevertheless includes provisions that would increase the likelihood of successful communication.²⁸⁷

Communications expert Percy Tannenbaum believes that we cannot form a dependable warning message without knowing more about the message recipients and how they will process the information presented in the WIPP site. Tannenbaum notes that "there are certain characteristics of humans that are so widespread across individuals and cultures as to be considered as being intrinsic in their perceptual makeup."²⁸⁸ It therefore seems that the types of information related to these consistencies can be communicated with some degree of dependability. However, this "still leaves a good deal of desired content to be communicated and for which our present knowledge base is totally

²⁸⁶ Sebeok, 2.

²⁸⁷ These provisions are very similar to David Givens' "semiotic Lessons learned from antiquity, which are listed on page number 50 of this paper.

²⁸⁸ Tannenbaum, 41.

inadequate to guide the selection process."²⁸⁹ Tannenbaum expects that with his suggested research, a more dependable strategy for communicating with the distant future may be formed.

However, in the field of semiotics, Structuralist and Poststructuralist thought differ on whether deep time communication is at all possible. Although the Structuralists note that the sign is not necessarily rooted in the "thing," they believe that the sign is deeply rooted within the structure of language and culture, an "immense dictionary" from which the artist or writer draws upon.²⁹⁰ "Things" have no place in the model.²⁹¹ Poststructuralist thought, born out of Structuralist theories, considers the relationship between the signifier and signified much more unstable. In his work, Sausurre notes that there is not necessarily a connection between the signifier and signified:

Sometimes language will have one word (signifier) for two concepts (signifieds): in English "sheep" is the animal and "mutton" is the meat; French has only one word for both signifieds ("mouton"). It is as though the various languages carve up the world of things and ideas into different concepts (signifieds) on the one hand, and different words (signifiers) on the other.²⁹²

This instability permeates the world of image-signifiers and well as word-signifiers. Consider the different meanings that the swastika symbol has taken on in various cultures throughout time. In many sects of Buddhism it is an auspicious symbol — representing life, sun, power, and good luck — but in most of the Western world it represents the legacy of Nazi Germany and acts as a symbol of racism.

Poststructuralist thought, in this sense, is more attuned to the concept of a pluralistic human society than Structuralist thought. "Meaning" is sensitive to context, and can vary from culture to culture as well as from time period to time period. Poststructuralists note that "...the sign is not so much a unit with two sides (the signifier and the signified) as a momentary 'fix' between two moving layers."²⁹³ An example of this migration of meaning can be witnessed by opening any dictionary. Most words, such as 'bed' or 'crib' will have multiple meanings, depending on the context in which the

²⁸⁹ Ibid, 42.

²⁹⁰ Ramen Selden and Peter Widdowson, *Contemporary Literary Theory*, (Lexington: University of Kentucky Press, 1993), 103.

²⁹¹ Sausurre's model of the sign is as follows: "SIGN= signifier + signified The elements of language acquire meaning not as the result of some connection between words and things, but only as parts of a system of relations. Consider the sign-system of traffic lights: red-amber-green signifier('red')/signified (stop) (Ramen Selden and Peter Widdowson, *Contemporary Literary Theory*, (Lexington: University of Kentucky Press, 1993), 105.)
²⁹² Selden, 126.

²⁹³ Ibid.

word is used.²⁹⁴ Some of the meanings may be completely unfamiliar to the modern reader. Poststructuralists believe that this "…process continues interminably, as the signifiers lead a chameleon-like existence, changing their colors with each new context."²⁹⁵ This explains why language changes so rapidly from century to century, and why the WIPP teams are using language only peripherally in the marker design.

Limits to the Design of Information

In addition to (and inextricably linked to) the limits of language and the slippery nature of meaning in both verbal and non-verbal communication, there also exists a limitation to clear communication in information design. Like text, information and communication design graphics — while striving for 'clarity' — are polysemic; they too allow multiple readings. Design expert, Robin Kinross, suggests that even railroad timetables — which are specifically designed to only communicate one specific set of facts — are not neutral, but make rhetorical statements about the organizations that publish them.²⁹⁶

An additional problem, perhaps more unique to the discipline of information design is noted by Edward Tufte. Tufte asserts that certain message systems simplify and flatten information — to the extent that they misinform the reader by burying the important content. He most famously refutes the "cognitive style" of the slide presentation software, PowerPoint, whose

Impoverished space leads to over-generalizations, imprecise statements, slogans, lightweight evidence, abrupt and thinly-argued claims...With so little information per slide, many many slides are needed...When information is stacked in time, it is difficult to understand context and evaluate relationships. Visual reasoning works more effectively when the relevant information is shown adjacent in space within our eyespan.²⁰⁷

Tufte points to an example wherein flat, information-sparse design caused a concealment from the truth — resulting in dramatic consequences. In 2003, shortly after the liftoff of the Columbia space shuttle, the craft suffered damage to its left wing which would eventually lead to its destruction. In response to the initial wing damage, engineers from the Boeing Corporation prepared three quick

²⁹⁴ Ibid.

²⁹⁵ Selden, 127.

²⁹⁶ Robin Kinross, "The Rhetoric of Neutrality," *Design Issues*, 2, no. 2 (1986) 18.

²⁹⁷ Edward Tufte, The Cognitive Style of PowerPoint, (Cheshire, Connecticut: Graphics Press, 2003), 4.

PowerPoint presentations which showed their assessment of the damage.²⁹⁸ According to Tufte's analysis, these PowerPoint presentations failed to inform NASA of the actual dangers of the wing damage because the format is "medieval in its preoccupation with hierarchical distinctions" and "completely indifferent to content."²⁹⁹ With his own clear, effective information graphics, Tufte analyzes how the information graphics generated by Boeing buried the essential content of their presentation. (See Figure 54) In other instance, Tufte suggests that information-flattening via electronic slides may have helped Secretary of State Colin Powell make his case to the United Nations for declaring war on Iraq.³⁰⁰

Of course no plans were mentioned indicating that a PowerPoint-style message system would be used at the WIPP site, Tufte's point regarding the flattening and simplification of information relates directly to the perils inherent in Givens' message system. Because Givens' "Levels" requires that the danger of the WIPP site be expressed in varying degrees of simplicity, the lower-numbered, simpler messages will necessarily exclude information from the reader. The more sophisticated, Level V messages explain — in a very objective manner — which radioactive materials are buried at the site (and where), as well as the specific danger that they pose to human beings. The Level I and II messages, on the other hand, only communicate the man-made nature of the marker and that there is danger, which gives the reader neither enough information to locate the threat nor to understand the extent of the threat. However, the flattening of information that occurs in Givens' system of levels is a necessary side effect of the vagueness of deep time communication. Because there is no way to anticipate what the future message recipients will and will not understand, providing a whole range of messages is the best strategy to compensate for this uncertainty.

However, font designer David Kindersley believes that varying levels of communication — with its varying levels of information — is an inherent, and perhaps positive, aspect of information design. In his *Graphic Variations*, he writes

²⁹⁸ Ibid, 7.

²⁹⁹ Ibid, 10.

³⁰⁰ Edward Tufte, "Response to Colin Powell's WMD Presentation to the UN," The Work of Edward Tufte and Graphics Press, http://www.edwardtufte.com/bboard/q-and-a-fetchmsg?msg_id=0000YU&topic_id=1&topic=Ask+ E%2eT%2e.)

I tried to make the letters and their arranging express the particular saying. This is the area in which I would most like to work. These sayings carry meanings at differing levels of understanding, and understanding comes and goes, depending on mood and attention. One tries to create a 'set' that will lead the reader or viewer deeper into the meaning behind the words. Some are deliberately difficult to read, in the hope that a superficial understanding will be avoided.³⁰¹

In this view of the problem, the WIPP marker will be faced with the challenge of encouraging readers to read more deeply into the meaning of the marker — by decoding the more sophisticated, higher-level messages. Keeping natural human curiosity in mind, it is easy to believe that the people of the future will be inclined to translate these higher-level messages. However, it seems equally likely that they may dig to try to find clues to aid in their decoding.

Beyond "low resolution" information systems that lack an adequate depth of information, according to Tufte, there are additional pitfalls to avoid in the creation of information design. Text and graphics, for example, lose their effectiveness when separated from one another — since physical distance hinders their correlation in the human brain.³⁰² This may be a problem within the WIPP site, since (as discussed on pp 26-27) the team members found that certain types/levels of messages are best expressed by different mediums and by different scales. For example, emotional connotative messages were found to be more effective when writ large in the form of a large monument yielding a striking visual impact. Analytical denotative messages, on the other hand, are best communicated through text — or the closest visual equivalent to text, pictograms. Because of the scale disparity between these two types of message systems, the viewer will be unable to simultaneously experience both types of messages, which will possibly hamper their understanding of the site's overall message. It will be difficult to overcome this particular shortcoming of the site, since the problem stems from the inherent nature of the message systems.

Concluding Comments on the Success or Failure of the WIPP Marker

In spite of the careful logic — and often insightful and creative thinking — on the part of the WIPP expert panels, it is impossible to gaze into the future and judge the success of their efforts. Given the odds — 10,000 years of uncertainly are aligned against the possibility of success — it seems

³⁰¹ David Kindersley, *Graphic variations,* (Cambridge, England: David Kindersley & Lida Lopes Cardozo, 1979), pages unnumbered.

doubtful that the marker will be able to ward off all human intrusion. However, since there is no way to know which warning measures will and will not be effective, intelligent and creative approaches to the problem should continue to be investigated. In this sense, the odds lie on the side of the WIPP project — the more strategies that can be employed to warn, the more likely that a warning will be understood.

It is possible however, as a case study of a design process, to judge the methodology of the WIPP. Although the Markers panels openly regarded pluralism as an asset in the design process — frequently noting the interdisciplinary makeup of the design team — no team member criticized the project for its lack of international collaboration. Tannenbaum, although mentioning the distal markers for nuclear facility sites in Europe, did not suggest that the designers of those signs offer input on the WIPP marker design. Organizations such as The Communication Research Institute of Australia, whose stated objective is "to engage in research, publication, training, the provision of forums for discussion, and similar activities in the field of communication," may be helpful source of information in subsequent discussions on the WIPP markers.³⁰³ Testing is used as an integral part of their design process — in an attempt to narrow down the range of unproductive multiple meanings to an acceptable level. Similarly, in the Symbol Signs project, AIGA rigorously tested their final symbol choices on an international array of subjects in order to arrive at the most successful icons. Because of the lack of design testing, the WIPP project seems incomplete. Within the ninety-one years remaining until the switch to passive control of the WIPP site, a stronger, more thorough design system must be implemented that builds on the findings and suggestions of the 1991 Marker design teams.

³⁰² For an example, consider the lack of text-image correlation of this paper. All graphics, referred to by an intermediary "figure number" are quarantined from the text, thus senselessly making the reader work harder to synthesize the information. ³⁰³ Communication Institute of Australia, "About Us," *Communication Institute of Australia*,

http://www.communication.org.au/html/about us.html.

APPENDIX A

From:

Sandia National Laboratories. Expert Judgment on Markers to Deter Inadvertent Human Intrusion into the Waste Isolation Pilot Plant, report SAND92-1382 / UC-721. Washington: Division of High-Level Waste Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, 1992.

4.1 Site design guidelines for a design of the entire site, so it is a major component of a system of messages

The Design Guidelines herein will be largely *performance-based*, that is, they describe how the design must *perform*, rather than what it must look like or be made of. These guidelines can, in turn, be used as criteria to evaluate designs. Because performance-based design guidelines do not describe the design, but rather what ht edesign must do, several alternative designs can be developed in response to the guidelines. We have developed designs using the design guidelines, both as a test of the utility of the guidelines and as an expression of the team's preferred solutions. Because all the designs cover the entire interment, and then some, we refer to them as "site designs." These designs are presented in Section 4.2.

In this discussion and then later in the descriptions of the designs that test these design guidelines we will use the expression "the Keep" to define an area whose size and shape is the "footprint" or the vertical projection on the site's surface of the final interment area. Our team's analysis suggests that the final footprint may be larger than currently shown because of both migration of radionuclides in the salt and future expansion.

The various site designs may be listed as follows:

* The site must be marked.

* All levels of message complexity should be located on-ste. Thus, communication vehicles for information at Levels I, II, III, and IV should be on the WIPP site and available to humans. As well, this team has developed specific message content for each level, presented later in Section 4.6.

* The design of the whole site itself is to be a major source of meaning, acting as a framework for other levels of communication, reinforcing and being reinforced by those other levels in a system of communication. The message that we believe can be communication *non*-linguistically (through the design of the whole site), using physical form as a "natural language," encompasses Level I and portions (faces showing horror and sickness) of Level II. Put into words, it would communicate something like the following:

- * This place is a message... and part of a system of messages... pay attention to it!
- * Sending this message was impotant to us. We considered ourselves to be a powerful culture.
- This place is not a place of honor...no highly esteemed deed is commemorated here... nothing valued is here.
 What is here is dangerous and repulsive to us. This message is a warning about danger.

The danger is in a particular location... it increases toward a center... the center of danger is here... of a
particular size and shape, and below us.

- The danger is still present, in your time, as it was in ours.
- * The danger is to the body, and it can kill.
- The form of the danger is an emanation of energy.

* The danger is unleashed only if you substantially disturb this place physically. This place is best shunned and left uninhabited.

* All physical site interventions and markings must be understood as communicating a message. It is not enough to know that this is a place of importance and danger...you must know that the place itself is a message, that it contains messages, and is part of a system of messages, and is a system with redundance.

* Redundancy of message communication is important to message survivability. Redundancy should be achieved through: (a) a high frequency of message locations, permitting some to be lost; (b) making direct and physical links among message levels, that is "co-presentation" of messages; and (c) multiple and mutually reinforcing modes of communication.

It is expected that the number of presentations of messages will decrease as the message complexity (or Level) increases. Thus, there will be many more presentations of Level II liquistic messages than of Level IV.

While the system of marking should strongly embody the principles of redundancy, at the same time the methods of achieving redundancy should be carefully designed to maintain message clarity. Redundancy should not be achieved at the expense of clarity.

* The method of site-marking must be very powerful to distinguish this place from all other types of places, so that the future must pay attention to this site. The place's physical structure should strongly suggest enhanced attention to itself and to its subelements. To achieve this, the volume of human effort used to make and mark this place must be understood as massive, emphasizing its *importance* to us. The site's constructions must be seen as an effort at the scale of a grand and committed culture, far beyond what a group or sect or organization could do.

About scale: "Scale" refers to the perceived size relationship between a human and something (like a house or a chair or a site). When the size of a thing gets far larger than a person, changes in scale are not easily perceived or are experienced as irrelevant. Thus, there is little difference to a person at ground level whether an earthwork is 1 mile or 2 miles long. These distances are experienced as much the same. What we propose as a marking for this site is already at a scale where it could be somewhat smaller or larger with no loss of meaning. And further, if the design were to be replicated elsewhere, it could be (somewhat) scaled up or down with no loss of meaning.

* Vertical masonry markers alone are simply not enough to accomplish our purposes. They are not large enough, nor frequent enough, nor sufficiently distinguishing from other sites already so marked; and their use elsewhere may well make their use here somewhat trivial and certainly ambguous. If only markers are used here, they will be seen as much like markers on other sites, which are generally sites of far less import, and also tend to be marked because they are honorific or commemorative, the opposite of the message we seek to send.

* Use a system of markeings that utilizes the whole site as an enormous mark, and that includes: smaller markers; high points to climb from which to view the entire site; walls and places to be in that co-locate viewers with messaegs...an organized environment. Consider the possible retention of a currently existing structure for symbolic purposes only, as a decaying massiveness.

As for use of existing-ste structures, if we assume no active institutional control, the only current above-ground site structure that might endure for a substantial portion of the 10,000 years would be the thick-walled concrete "hot" cell. The other buildings will decay, or more probably be stripped of their valuable building materials for re-use.

The "hot" cell may be put to symbolic use by incorporating it into the site's design, as a mute artifact suggesting something "strong" that needed to be contained, although from its large door size, a thing that had to be easily accessible and thus

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ILLUSTRATIONS



1 *Project Gnome Marker*, 1961 *Source:* http://www.atomictourist.com/images/gnome1.jpg



Indicates probability values needed to determine probability of scenario R2, T1, T3

Probability of R2, T1, T3 = (.60)(.20)(.30)(.95)(.01) = 3.4 x 10⁻⁴

2 Example of the Calculation of the Probability of Occurrence of a Scenario

Source: R. V. Guzowski and M. M. Gruebel, ed., Background Information Presented to the Expert Panel on Inadvertent Human Intrusion into the Waste Isolation Pilot Plant (Albuquerque: Sandia National Laboratories, 1991), pl. 2.3. 97

Type of Uncertainty	Technique for Assessing or Reducing Uncertainty
Scenarios (Completeness, Logic, and Probabilities)	Expert Judgment and Peer Review; Quality Assurance
Conceptual Models	Expert Judgment and Peer Review; Sensitivity Analysis; Quality Assurance
Computer Models	Expert Judgment and Peer Review; Verification and Validation*; Sensitivity Analysis; Quality Assurance
Parameter Values and Variability	Expert Judgment and Peer Review; Data-Collection Programs; Sampling Techniques; Sensitivity Analysis; Uncertainty Analysis; Quality Assurance
*to the extent possible	

TABLE III-1. TECHNIQUES FOR ASSESSING AND REDUCING UNCERTAINTY IN THE WIPP PERFORMANCE ASSESSMENT (after Bertram-Howery and Hunter, 1989)

3 Techniques for Assessing and Reducing Uncertainty in the WIPP Performance Assessment

Source: R. V. Guzowski and M. M. Gruebel, ed., Background Information Presented to the Expert Panel on Inadvertent Human Intrusion into the Waste Isolation Pilot Plant (Albuquerque: Sandia National Laboratories, 1991), pl. III-!.



4 The Mole Miner

Source: Gregory Benford, *Deep Time: How Humanity Communicates Across Millennia*, 1st ed. (New York: Perennial, 1999), pl. 1.1.



5 The Pyramids of Menkaure (c. 2533-2515 B.C.), Khafre (2570-2544 B.C.), and Khufu (c. 2601-2528 B.C.), Giza

Source: Anthony F Janson, History of Art, 6th Edition, (New Jersey: Prentice Hall, 2004), pl. 2-9.





Source: Anthony F Janson, History of Art, 6th Edition, (New Jersey: Prentice Hall, 2004), pl. 2-11.



7 Stonehenge (aerial view), 2000 B.C. Source: Anthony F Janson, *History of Art*, 6th Edition, (New Jersey: Prentice Hall, 2004), pl. 1-18 and1-19.


8 The Great Wall of China, 221 BC- 210BC

Source: Art Resources Image Database, http://www.artres.com.



9 Great Serpent Mound, Adams County, Ohio. C. 1070 AD

Source: Anthony F Janson, *History of Art*, 6th Edition, (New Jersey: Prentice Hall, 2004), pl. 1-20.



10 Avebury, 2800 BC

Source: http://contrapuntus.net/photo/pcd4096/072avebury.3.jpg.



11 The Treasury of Petra, c. 4^{th} century BC

Source: Art Resources, Image Database, http://www.artres.com.



12 Options for the Warning Symbol for Nuclear Waste Disposal Sites

Source: Maureen F. Kaplan, "Mankind's Future: Using the Past to Protect the Future; Archaeology and the Disposal of Highly Radioactive Wastes," *Interdisciplinary Science Reviews*, 11, no. 3 (1986), pl. 6.



13 Pictograph for the Location of a Repository for Reprocessed High-level Wastes

Source: Maureen F. Kaplan, "Mankind's Future: Using the Past to Protect the Future; Archaeology and the Disposal of Highly Radioactive Wastes," *Interdisciplinary Science Reviews*, 11, no. 3 (1986), pl. 7.



14 Pictograph Developed by the Human Interference Task Force Indicating the Consequences of Disrupting the Disposal Site

Source: Maureen F. Kaplan, "Mankind's Future: Using the Past to Protect the Future; Archaeology and the Disposal of Highly Radioactive Wastes," *Interdisciplinary Science Reviews*, 11, no. 3 (1986), pl. 8.





The Parthenon at Athens, was built in the 5th century B.C. When its triangular pediment was intact, its dimensions could be fitted almost exactly into a Golden rectangle, as shown above.

15 The Parthenon

Source: Gregory Benford, *Deep Time: How Humanity Communicates Across Millennia*, 1st ed. (New York: Perennial, 1999), pl. 2.3.



Phaestos Disc, 1700 BC

Source: http://www.ancientscripts.com/Phaestos.html



17 Painting of Human Handprints about the Edges of Paintings of Horses in France's Pech Merle Cave, 35,000 BC

Source: <u>http://www.quercy.net/pechmerle/images/IMG0027_600.jpg</u>



 The Birdman from Lascaux, 15,000 BC Source: <u>http://news.bbc.co.uk/1/hi/sci/tech/871930.stm</u>







Flotilla Fresco, c. 1650 BC

Source: http://www.artres.com



20 /sotype, 1946

Source: http://www.newdeal.feri.org/ survey/37025.htm

Hyperfine transition of neutral hydrogen, a basic unit of time and distance throughout the physical universe.

Map of 14 pulsars locating the sun relative to pulsars and center of our galaxy. On the lines, binary digits denote pulse-times (deducible from their 10-decimal precision, an unlikely accuracy for stellar distances). With the hydrogen time-unit, an extraterrestrial analyst should realize that the times are about 0.1 second, a typical pulsar period. Since these periods decrease at known rates, pulsars serve as galactic clocks. Thus an advanced civilization could review its galactic database and identify the origin and time of launch, even if Pioneer is not discovered until several billion years from now.



21 *Imagery from Voyager*

Source: Edward Tufte, Visual Explanations: Images and Quantities, Evidence and Narrative, (Cheshire, Conn.: Graphics Press, 1997), pl. 27.

Outline drawings of humans (with prominent four fingers and opposing thumb), drawn in proportion to the Pioneer spacecraft in the background. Note the visual convention of the opacity of outline drawing as well as the lack of shadows.

> Binary equivalent of decimal 8, between tick marks indicating human heights. The hydrogen wavelength (21.11 cm) multiplied by 8 yields the woman's height (169 cm or 66 in).

Planets of solar system (note Saturn's rings), binary relative distances, and path indicating origin of Pioneer (which points back toward Earth).



22 Upper Strip Looking North

Source: Robert Venturi, Denise Scott Brown, and Steven Izenour, *Learning from Las Vegas: The Forgotten Symbolism of Architectural Form*, (Cambridge: MIT Press, 1977), pl. 36.



23 Computer Kiosk Interface Design for the National Gallery in Washington

Source: Source: Edward Tufte, Visual Explanations: Images and Quantities, Evidence and Narrative, (Cheshire, Conn.: Graphics Press, 1997), p 47.

ananananananananananananananananananan	
KEEP OUT	

24 Elements of Legibility



25 Variations on Triangles and Circles

Source: Percy H. Tannenbaum, *Communication Across 300 Generations: Deterring Human Interference with Waste Deposit Sites*. Columbus: Office of Nuclear Waste Isolation, Battelle Memorial Institute, 1984, pl. 1.





26 Mail

Source: American Institute of Graphic Arts. Symbol Signs: the development of passenger/pedestrian oriented symbols for use in transportation-related facilities. Washington: Dept. of Transportation, Assistant Secretary for Environment, Safety and Consumer Affairs, Office of Facilities, 1974, pg. 16.

Telephone



27 Telephone

Source: American Institute of Graphic Arts. Symbol Signs: the development of passenger/pedestrian oriented symbols for use in transportation-related facilities. Washington: Dept. of Transportation, Assistant Secretary for Environment, Safety and Consumer Affairs, Office of Facilities, 1974, pg. 14.

	Telephone	Concept Description	Symbol Source	Eval	ation	and and a start	Symbol Design Recommendations
1	$\left[\begin{array}{c c} & & & \\ \hline \hline & & \\ \hline \hline & & \\ \hline & & \\ \hline \\ \hline$	1 Telephone handset.	X'67 O72 ATA UIC BAA S.TA S.F UIC DIFW X'70 PG NPS KFAI NRR TA POT ICAO ADV	5 5 5 5 5 5 5 4 4 5 5 5 4 5 5 5 5 5 5 5	- * * * * * * * * * * * * * * * * * * *	5	This message presents a dilemma for the committee. The inventory clearly shows that the telephone handset is widely used around the world. But it is an awkward shape, one that might be confused with other symbols, such as the wrench used in highway signs to represent repairs. To the committee, both the telephone dial, O'64, and the front view of the telephone. O 68, are clearer representations of a phone. The problem is that they represent tooslete telephone styles. While it is not our intention to develop new symbols where another has already been well established, we believe that the symbol used for telephone is one of the casiest to establish because the instrument is so universally used and known. Therefore, we advise that in addition to develop if a satisfactory drawing of a handset, there should be experiments with a front view of an up-to-date phone. We feel that none of the drawings of the handsets are completely satisfactory. The object should not be over simplified and abstracted, as for example the X70 version. It should also not be merely a photographic depiction. I ke the ICAO version angle. That decision should involve an evaluation of the relationships between this drawing and the others in the initial group.
2	TA Port TC ICAO ADV	2 Telephone dial.	0.68	5 !	5	5	Summary: Modify drawing of Group 1 concept; experiment with front view of modern telephone.
3		3 Front view of dial telephone.	0'64	5 5	4	5	
4	084	4 Handset and dial.	ADAC	3 4	2	3	
	ADCA						

28 Symbol Evaluation Chart

Source: American Institute of Graphic Arts. *Symbol Signs: the development of passenger/pedestrian oriented symbols for use in transportation-related facilities.* Washington: Dept. of Transportation, Assistant Secretary for Environment, Safety and Consumer Affairs, Office of Facilities, 1974, pg. 13-14.



29 Exterior of the WIPP, 1991

Source: http://www.icsicontrols.com/show_wipp.htm



Satellite Image of the WIPP, 2005

Source: Google Maps, http://www.maps.google.com



31 Waste Isolation Pilot Project, Carlsbad, New Mexico

Source: Tom Vanderbilt, Survival City: Adventures Among the Ruins of Atomic America, (New York: Princeton Architectural Press, 2002), pg. 190.



32 Waste-handling Building

Source: R. V. Guzowski and M. M. Gruebel, ed., Background Information Presented to the Expert Panel on Inadvertent Human Intrusion into the Waste Isolation Pilot Plant (Albuquerque: Sandia National Laboratories, 1991), pl. II-6.



33 Transuranic Nuclear Waste Housed 2,150 feet below the Earth's Surface, Waste Isolation Pilot Project

Source: Tom Vanderbilt, Survival City: Adventures Among the Ruins of Atomic America, (New York: Princeton Architectural Press, 2002), pg. 187.



34 Black Hole

Source: Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 8.



35 Black Hole

Source: Michael Brill, *Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years*. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 9.



36 Rubble Landscape

Source: Michael Brill, *Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years.* Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 10.



37 Rubble Landscape

Source: Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 11.



38 Spike Field

Source: Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 6.



39 Spike Field

Source: Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 7.



40 Spikes Bursting Through Grid

Source: Michael Brill, *Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years*. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 14.



41 Spikes Bursting Through Grid

Source: Michael Brill, *Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years*. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 15.



42 Leaning Stone Spikes

Source: Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 19.



43 Landscape of Thorns

Source: Michael Brill, *Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years*. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 1.


44 Landscape of Thorns

Source: Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 2.



45 Menacing Earthworks

Source: Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 3.



46 Menacing Earthworks

Source: Michael Brill, *Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years*. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 4.



47 Menacing Earthworks

Source: Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 5.



48 Walk-on Map of All Radioactive Burial Sites

Source: Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 18.



49 Forbidding Blocks

Source: Michael Brill, *Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years*. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 12.



50 Forbidding Blocks

Source: Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 13.



51 Buried Room

Source: Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 17.



52 Message Kiosk

Source: Michael Brill, Site Design to Mark the Dangers of Nuclear Waste for 10,000 Years. Buffalo: The Buffalo Organization for Social and Technological Innovation Inc. (BOSTI), 1991, pl. 16.



53 Tilted Arc, 1981

Source: Clara Weyergraf-Serra and Martha Buskirk, ed., *The Destruction of* Tilted Arc: *Documents*, (Cambridge: MIT Press, 1991.), pg. 50.

gracefully. If PowerPoint is a corporate-mandated format Shakiness in conventions for units of measurement should for all engineering reports, then some competent scientific significantly" are used 5 times on this slide, with de facto calibration case study" to "an amount of damage so that As is the case here, such phrases may well be ambiguous. The low resolution and large font generate 3 typographic meanings ranging from "detectable in largely irrelevant ambiguous language (sentence fragments, passive voice, that the Columbia was not in danger, the officials made rather than in clear and tidy exponential form 1920 in³ None of these 5 usages appears to refer to the technical meaning who were deciding whether the threat of wing damage attempted to return. Satisfied that the reports indicated no further attempts to assess the threat. The slides were provoke concern.* Slides with hierarchical bullet-outli Columbia. The slide weakens important material with were created by engineers for high-level NASA officials essential. In this slide, the typography is so choppy and typography (rather than the PP market-pitch style) is the use of compressed phrases like "Tile Penetration." part of an oral presentation, later circulated as e-mail This vague pronoun reference "it" alludes to damage required further investigation before the Columbia do not handle statistical data and scientific notation The low resolution of PowerPoint slides promotes to the left wing, which caused the destruction of the multiple meanings of "significant"). The 3 reports (cubic inches) is shown a different way every time and orphans, lonely words dangling on a separate line: 3cu. In Perhaps the available font cannot show exponents In this slide the same unit of measure for volume The vaguely quantitative words "significant" everyone dies" to "a difference of 640-fold." 3 cu in Penetration significantly clunky that it impedes understanding. 1920cu in of "statistical significance." 3cu. In attachments. ~



54 The Key Slide in the Boeing PowerPoint Source: Edward Tufte, The Cognitive Style of PowerPoint, (Cheshire, Conn.: Graphics Press, 2003), p 8-9.

of the headline fades away.

quantitative assessments.

The final bullet will tell us.

 little bullet diamond

 Very Big Bullet Title of Slide - dash

Level 2 Level 1 Level 3 Level 4 Level 5 Level 6